# TRANSACTIONS

OF THE

# Illinois State Academy of Science

## THIRTEENTH ANNUAL MEETING

DANVILLE

February 20-21, 1920

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*Vice-President*, Chas. T. Knipp, University of Illinois, Urbana.
*Secretary*,* J. L. Pricer, State Normal University, Normal.
*Treasurer*, W. G. Waterman, Northwestern University, Evanston.
*Librarian*, A. R. Crook, State Museum, Springfield.

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### *Committee on Membership.*

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W. J. Risley, James Millikin University, Decatur.
W. G. Bain, Springfield.
Rollin T. Chamberlin, University of Chicago, Chicago.
W. L. Woodburn, Northwestern University, Evanston.

### *Committee on Ecological Survey.*

Henry C. Cowles, University of Chicago, Chicago, Chairman.
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W. G. Waterman, Northwestern University, Evanston.
V. E. Shelford, University of Illinois, Urbana.
W. B. McDougall, University of Illinois, Urbana.
R. B. Miller, State Natural History Survey, Urbana.
S. A. Forbes, University of Illinois, Urbana.
A. G. Vestal, State Normal School, Charleston.
H. S. Pepoon, Lake View High School, Chicago.
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### *Committee on Legislation.*

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R. M. Barnes, Lacon.
Geo. Langford, Joliet.

### *Committee on Publications.*

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*The Secretary,*
Prof. W. H. Haas, Northwestern University.

### *Committee on Publicity and Promotion.*

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W. G. Watermann, Evanston.
R. H. Linkins, Normal.
H. S. Pepoon, Chicago.

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* Deceased, August 1920.

## PAST OFFICERS OF THE ACADEMY

1908

*President*, T. C. Chamberlin, University of Chicago.
*Vice-President*, Henry Crew, Northwestern University.
*Secretary*, A. R. Crook, State Museum of Natural History.
*Treasurer*, J. C. Hessler, James Millikin University.

1909

*President*, S. A. Forbes, University of Illinois.
*Vice-President*, John M. Coulter, University of Chicago.
*Secretary*, A. R. Crook, State Museum of Natural History.
*Treasurer*, J. C. Hessler, James Millikin University.

1910

*President*, John M. Coulter, University of Chicago.
*Vice-President*, R. O. Graham, Illinois Wesleyan University.
*Secretary*, A. R. Crook, State Museum of Natural History.
*Treasurer*, J. C. Hessler, James Millikin University.

1911

*President*, W. A. Noyes, University of Illinois.
*Vice-President*, J. C. Udden, University of Texas.
*Secretary*, Frank C. Baker, Chicago Academy of Science.
*Treasurer*, J. C. Hessler, James Millikin University.

1912

*President*, Henry Crew, Northwestern University.
*Vice-President*, A. R. Crook, State Museum of Natural History
*Secretary*, Otis W. Caldwell, University of Chicago.
*Treasurer*, J. C. Hessler, James Millikin University.

1913

*President*, Frank W. DeWolf, State Geological Survey.
*Vice-President*, H. S. Pepoon, Lake View High School, Chicago.
*Secretary*, E. N. Transeau, Eastern Illinois Normal School.
*Treasurer*, J. C. Hessler, James Millikin University.

1914

*President*, A. R. Crook, State Museum, Springfield.
*Vice-President*, U. S. Grant, Northwestern University, Evanston.
*Secretary*, Edgar N. Transeau, Eastern State Normal School, Charleston.
*Treasurer*, J. C. Hessler, James Millikin University.

1915

*President*, U. S. Grant, Northwestern University, Evanston.
*Vice-President*, E. W. Washburn, University of Illinois, Urbana.
*Secretary*, A. R. Crook, State Museum, Springfield.
*Treasurer*, H. S. Pepoon, Lake View High School, Chicago.

1916

*President*, William Trelease, University of Illinois, Urbana.
*Vice-President*, H. E. Griffith, Knox College, Galesburg.
*Secretary*, J. L. Pricer, State Normal University, Normal.
*Treasurer*, H. S. Pepoon, Lake View High School, Chicago.
*Librarian*, A. R. Crook, State Museum, Springfield.

1917

*President*, J. C. Hessler, James Millikin University, Decatur.
*Vice-President*, James H. Ferriss, Joliet.
*Secretary*, J. L. Pricer, State Normal, University, Normal.
*Treasurer*, T. L. Hankinson, State Normal School, Charleston.
*Librarian*, A. R. Crook, State Museum, Springfield.

1918

*President*, R. D. SALLISBURY, University of Chicago, Chicago.
*Vice-President*, ISABEL S. SMITH, Illinois College, Jacsonville.
*Secretary*, J. L. PRICER, State Normal, University, Normal.
*Treasurer*, T. L. HANKINSON, State Normal School, Charleston.
*Librarian*, A. R. CROOK, State Museum, Springfield.

1919

*President*, HENRY B. WARD, University of Illinois, Urbana.
*Vice-President*, GEO. D. FULLER, University of Chicago, Chicago.
*Secretary*, J. L. PRICER, State Normal University, Normal.
*Treasurer*, W. G. WATERMAN, Northwestern University, Evanston.
*Librarian*, A. R. CROOK, State Museum, Springfield.

## MINUTES OF THE THIRTEENTH ANNUAL MEETING

The meeting was called to order in the Chamber of Commerce auditorium, Danville, at 11:00 A. M. Friday, February 20, 1920, by Dr. Henry B. Ward, President of the Academy.

President Ward stated that since the minutes of the previous meeting would be printed in the transactions, they would not be read. Reports were made by the secretary, the treasurer, and the librarian. These reports appear later in this volume.

President Ward made a brief oral report for Dr. S. A. Forbes as chairman of the committee on Ecological Survey. Dr Forbes was unable to attend the meeting and asked Dr. Ward to say for him that he felt that the committee had about completed the work which it had originally set out to do, and that therefore, he wished to resign as its chairman, but hoped that the committee might go forward under other leadership to do other similar work. On motion, Dr. Forbes's resignation was accepted and Dr. Henry C. Cowles was elected to succeed him as chairman of the committee. A motion was made and carried that Dr. Cowles should be empowered to add members to the committee at his own discretion.

J. L. Pricer made a brief oral report for the committee appointed the previous year to secure the affiliation of high school science clubs with the Academy. The committee was continued with instructions to continue its efforts along this line for another year.

Dr. Bain and Professor Risley were appointed as a committee on auditing and the treasurer's report was referred to this committee.

After a general discussion of the matter of disposing of back numbers of the Academy Transactions, it was voted that the librarian be allowed to use his discretion in disposing of these publications following a conservative policy.

After thorough discussion, the Academy voted unanimously to become affiliated with the American Association for the Advancement of Science on the terms proposed by the latter organization. These terms are set forth in the Secretary's report printed later in this volume. Next, the Academy voted to adopt an amendment to the constitution, in the form of a complete revision of Article III on membership. This revision includes provisions for the affiliated relationship with the American Association. The revised form of this article on membership is printed in the constitution in this volume.

After this business session, the Academy adjourned for luncheon and reassembled at the same place at 1:30 P. M. for the reading of papers. At 6:00 P M., the Academy members present and three Danville citizens enjoyed a delightful banquet and program of toasts at Elk's Hall. At 8:15 P. M., President Ward delivered an admirable illustrated lecture on "Alaska and Its Riches", to the Academy members in attendance and a small audience of Danville people.

At 8:00 A. M. Saturday morning, a large number of the Academy members made a visit to the Hegeler Zinc Plant in Danville, and at 10:00 A M. another general session for the reading of papers was held. At 1:30 P. M., a brief business session was held and the remaining time until adjournment at 4:00 P. M., was devoted to the reading of papers.

At the business session, 105 applicants were elected to membership in the Academy. On the recommendation of the Council, it was voted unanimously to divide the Academy into six section meetings for one half day session at the 1921 annual meeting. The following sections were suggested and the Council was empowered to select chairmen for them—; Medicine and Public Health; Biology and Agriculture; Geology and Geography; Chemistry and Physics; Mathematics and allied Sciences; Education and Psychology.

Professor Frank Smith, chairman of the committee on nominations proposed the following as officers for the ensuing year:

For President—Henry C. Cowles, University of Chicago.

For Vice President—Chas. T. Knipp, University of Illinois.

For Secretary—J. L. Pricer, State Normal University.

For Treasurer—W. G. Waterman, Northwestern University.

For third member of the Publications Committee—Wm. H. Haas, Northwestern University.

For membership committee—H. J. Van Cleave, University of Illinois, chairman; W. J. Risley, James Millikin University; W. G. Bain, Springfield; Rollin T. Chamberlain, University of Chicago; W. L. Woodburn, Northwestern University.

On motion, the Secretary was instructed to cast the ballot for these officers and all were declared elected.

Dr. H. C. Cowles, newly elected chairman of the Committee on Ecological Survey, in conference with the committee on nominations, proposed the following as members of the committee:

H. C. Cowles, Chairman; Geo. D. Fuller, W. G. Waterman, V. E. Shelford, W. B. McDougall, R. B. Miller, S. A. Forbes, A. G. Vestal, H. S. Pepoon, Clarence Bonnell.

On motion, these were declared elected as members of the committee.

The committee on nominations suggested that the President appoint a committee on legislation.

About 100 members of the Academy and four delegates from the Indiana Academy of Science attended the meeting. More papers were offered for the program than could be presented in the time, and several had to be read by title only. The meeting was highly successful in every way except that the local people of Danville, almost completely failed to attend any of the sessions.

J. L. Pricer, Secretary.

# Reports of Officers

## REPORT OF THE SECRETARY

A meeting of the Council of the Academy was held at Urbana, Sept. 28, 1919 with the following members present: Ward, Crook, Waterman, and Pricer. Dr. H. J. Van Cleave, third member of the Committee on Publications also met with the Council.

The first matter of business was that of the publication of Volumes XI and XII of the Transactions. After due discussion, the Librarian was instructed to make requisition on the Superintendent of Printing of the State for the printing of the two volumes in editions of not less than 1,000 copies each. It is probable that the $750.00 available from the State for printing during the fiscal year ending June 30, 1920 will not be sufficient to pay for the two volumes, but the shortage will not be very great for the State has a good contract for printing which will make the cost much less than it would be through a private printer.

The Council and the Committee on Publications jointly considered the matter of furnishing free reprints of papers to authors. Considering the fact that the editions of the Transactions must be small, and the further fact that reprints constitute an excellent form for the dissemination of papers, it was decided to establish as a permanent policy of the Academy to furnish authors with 100 copies of their papers in reprint form, the authors to pay for special covers if they desire them. It was also decided that the reprints should bear on the back page a brief statement concerning the Academy, such as the number of years it has been organized, the number of members, the conditions of membership, the terms on which back numbers of Transactions may be had etc.

Considerable delay was experienced in getting the papers of these two volumes together. Most of the papers on the forestry survey were presented at the meeting last year in only tentative form, and the most of them were re-written and new drawings made. A good many of those who presented papers at the Joliet meeting had removed from the State, and were hard to locate. Finally, however, most of the papers were brought together

and prepared for the printer, and they have been in the hands of the State Superintendent of Printing since about the first of last month. I am expecting the galley proof any day. Proof will be sent to the authors for correction, and both volumes should be ready for distribution within the next two months.

The next matter of business of the Council meeting was the selection of the present place of meeting and the planning of the present program. These may speak for themselves without further comment.

During the St. Louis meeting of the American Association for the Advancement of Science, the President, the Librarian and the Secretary met with the Committee on Affiliations, of the A. A. A. S., where the terms of affiliations between state and local academies and the American Association were considered and perfected as finally adopted by the Council of the Association. These terms of affiliation as reported in Science Jan. 9, 1920, are as follows:

1. That state and local academies may be affiliated with the association on a financial basis that will yield the association $4.00 net per member.

2. That any state or local academy which concludes arrangements for affiliation within the first six months of 1920 may be accepted for the entire year 1920, fees paid to the association before that date to be adjusted in accordance with the detailed plan.

3. Two alternative plans are considered with respect to membership in the academies, namely:

(a) All members of the academy to become members of the association.

(b) To establish two grades of membership, of which one will be national, involving membership in both the academy and the association, the other local, consisting of academy members only.

4. The academies will collect joint dues and transmit the association's share to the treasurer.

Following the adoption of these terms of affiliation by the American Association, the President and the Secretary of the Academy have taken it upon themselves to

anticipate the acceptance of the terms by the Academy, by offering membership in the Academy and through the Academy in the American Association, in accordance with the terms of affiliation. About a month ago, the Secretary sent a letter and circular to something over seven hundred members of the A. A. A. S., living within the state, who are not members of the Academy inviting them to become members of the Academy on the payment of one dollar admission fee. As the report of the membership committee will show, a large number have accepted this invitation. It is hoped that many of the present local members of the Academy will improve this opportunity to become members of the Association.

## RECOMMENDATIONS

In the original constitution of the Academy, we find the statement that the Council shall consist of certain officers, and "a Chairman of each section that may be organized." This provision was omitted from the constitution by amendment, at the Joliet meeting when we were in the depths of dispair, over continued failure to secure proper recognition from the State. Conditions have so reversed themselves, now however that it is the belief of the Secretary that this provision should be revived, and certain sections organized. It has been our custom to have three half-day sessions and an evening session. I believe that one of these half day sessions might well be devoted to section meetings and that suitable sections should be organized for this purpose. Botany, zoology, and geology have usually furnished large numbers of papers, and we could surely have strong section meetings in these, but it seems to me that we should have almost equally strong sections representing other sciences if we had a suitable organization. Physics and chemistry might go together, physiology might join with zoology or botany, geography and geology might go together. In our general programs, we have paid a good deal of attention to medicine and public health, we ought to have a section representing this. We have also had a good many papers on the science of edu-

cation and education in science, we could have a section representing this. A few prominent mathematicians, have been faithful members of the Academy and at least one of these has suggested the desirability of having a section for mathematics. I believe that the organization of such sections would tend to at once broaden and intensify interest in the Academy, and to increase its usefulness. I hope that the suggestion will be fully considered, at the proper time. J. L. PRICER, Secretary.

## REPORT OF THE TREASURER FOR THE YEAR 1919-20

RECEIPTS

| | |
|---|---|
| Cash in Hand, March 24, 1919 | $ 17.28 |
| Membership dues collected | 176.35 |
| Cash from sale of transactions | 55.00 |
| Total receipts | $248.63 |

DISBURSEMENTS

| | |
|---|---|
| Stationery, postage and other expenses of officers | $ 61.76 |
| Exchange on checks | 1.10 |
| Paid in printer's bill for past volumes of transactions | 129.24 |
| Cash on hand Feb. 20, 1920 | 56.53 |
| | $248.63 |

We the undersigned have examined the above accounts and have checked the amounts against the vouchers. We find the same correct. WALTER G. BAIN,
W. J. RISLEY.

The auditing committee also requested and approved the following statement of financial status Feb. 20, 1920:

| | |
|---|---|
| Cash on hand | $ 56.53 |
| Bills receivable—back dues | 136.50 |
| Bills receivable—back dues donors | 17.00 |
| | 210.03 |
| Bills payable and approved Miller Printing Co., Balance | $103.95 |

## REPORT OF LIBRARIAN

Below is a list of volumes sold for the year 1919, up to February 15, 1920.

| Volume | Name | Price |
|---|---|---|
| VI | Syracuse Uni. Book Store | $ .75 |
| X | Amer. Museum Natural History | .75 |
| VI–X | Eastern Ill. State Normal | 3.00 |
| X | U. S. Dept. of Agriculture | .75 |
| X | Brooklyn Botanic Garden | .75 in stamps |
| X | U. S. Geol. Surv. Library | .75 |
| IX | Baker & Taylor Co., New York | .75 in stamps |
| Set | N. Y. Botanical Garden | 5.00 |
| IX | Baker & Taylor Co., New York | .75 in stamps |
| X | U. S. Dept. of the Interior | .75 |
| Set | Iowa State College | 5.50 |
| Set | University of Michigan | 5.50 |
| Set | Withers Pub. Library, Bloomington | 5.50 |
| VI–X | State University of Iowa | 3.75 |
| Set | New York College of Forestry | 5.50 |
| Set | University of Missouri Library | 5.50 |
| Set | New York Public Library | 5.50 |
| Set | Charles Deam | 5.50 |
| | | $56.25 |
| | Retained in stamps | 1.50 |
| | Handed to treasurer | $54.75 |

Checks for these amounts were sent to the treasurer as received.

The following volumes paid for by the State were sent in exchange gratis.

| Volume | Name | Price |
|---|---|---|
| IX | New York Public Library | Gratis |
| IX | U. S. Dept. of Agriculture | " |
| IX | U. S. Geological Surv. Library | " |
| IX | Field Museum Library | " |
| IV, V, IX | Representative B. M. Mitchell | " |
| IV, IX, X | McKendree College | " |

A. R. Crook, Librarian.

# Papers of General Interest

# THE DEVELOPMENT OF SMOKELESS FUEL FROM ILLINOIS COAL

S. W. Parr, University of Lllinois

Experiments directed toward the modification of the character of Illinois coals were begun in 1902, coincident with the strike of the miners in the anthracite field of Pennsylvania. While the lack of anthracite coal in the Illinois markets had none of the distressing features resulting from the hard coal famine of New England, still, the inconvenience was marked and the question very naturally arose as to whether we might not provide our own fuel of a smokeless type by devising some process of treatment applicable to Illinois coals which would bring them within the range of substitutes for anthracite.

The first published results of these experiments were given in the Year Book for 1906, issued as Bulletin No. 4 of the Illinois State Geological Survey, under the title "The Anthracizing of Bituminous Coal". This rather ambitious program and announcement seems, as we look back upon it, to be appropriately characterized as the exuberant expression of anticipatory zeal. At least, after the passing of ten or twelve years filled rather strenuously with investigational activities along this line, there is evidence of a greater mildness of announcement, if not born of wisdom then perhaps of experience and the very positive discovery of how much we do *not* know about coal.

However, a stage has been reached in recent months where we can properly consider that one chapter has been completed and another begun. The line of demarkation between chapters is not very distinct and the division relates more to the fact that a degree of progress has been attained where industrial scale operations are warranted and indeed essential before any final conclusions can be drawn as to the practicability of utilizing the results of purely scientific or laboratory investigations.

Of course, it will not be possible in eight or ten minutes to give any detail of the points covered by eighteen years

of work. Besides, a few accessory facts must be given, since these are essential to a fair appreciation of the relation such an investigation may bear to present-day tendencies in the industries.

Let us assume then, and we are ready to affirm from the purely scientific standpoint be it understood, that we can produce from Illinois coal a new type of fuel having the following characteristics:—It is of uniform texture; of good density and of ample strength to withstand handling and shipping, even, as we believe, of sufficient strength to sustain the burden and meet the requirements of blast furnace practice, though our original purpose and effort had in mind primarily the development of a domestic fuel. It has in its composition a definite amount of combustible matter which at red heat will assume the volatile form, hence, in combustion it burns with a flame though the flame is entitrely without smoke. The volatile matter thus referred to and amounting to from 8 to 12 per cent is a feature of very great importance, since because of it the necessity of special draft regulation is obviated. That is to say, the material will burn under the same draft conditions as are required for coal. If the draft is closed, the fire is still kept alive by reason of the availability of the volatile matter. This same condition exists in the case of the anthracite coal, though to a less degree, since the average anthracite has only about four per cent or one-half as great an amount of volatile matter.

In the making of it, there is produced per ton from the average Illinois coal approximately 20 gallons of oil, 6,000 cu. ft. of very high grade gas with an average heat value of about 700 units per cubic foot and 25 to 30 pounds of ammonium sulphate.

The statement of the problem is as simple as it is difficult of accomplishment: The decomposition of coal which begins at about 250° C delivers between that point and approximately 750° C all of those heavy volatile constituents which are condensible into tars and oils and which are difficultly combustible under the ordinary conditions of draft and temperature, hence wholly respon-

sible for the smoke, soot and grime which attend the combustion of bituminous coal in the raw state.

You will at once say therefore that it is a simple proposition of conducting a fractional distillation wherein the process is not allowed to exceed a temperature of 750° C. But there the difficulty is at once apparent of heating up a mass of non-conducting material through a range of 700° by means of the application of external heat which at once proceeds to build up against its own progress an impenetrable wall of greater non-conductivity between the source of heat and the mass to be heated. That, in concise form, is the statement of the problem. A detailed description of its solution as already noted would far exceed the time limit set for this paper. Certain accessory facts, however, are of interest and should be given in this connection:

The unmined coal reserves within the boundaries of the State of Illinois exceed the estimated tonnage of any other state in the Union, Pennsylvania and West Virginia *not* excepted. The average annual output of coal from this state is in round numbers from 90,000,000 to 100,000,000 tons. This yearly output is exceeded by Pennsylvania and in some years by West Virginia. It has a potential value annually as a source of oil on the basis of the investigations we are discussing to the extent of 2½ billion gallons, or approximately 1/5 of the entire annual petroleum output of the country. It has also a potential yield of 600 billion cubic feet of gas, an amount equal to the entire output of natural gas in the United States for the year 1915, and with an estimated value at that time of $100,000,000.

The above references to gas and oil may seem to be irrelevant but let us consider a few items in that connection. The modern industrial demand is increasingly urgent for fuels of the liquid and gaseous type. The generation of power by oil-burning, including gasoline-burning engines, in this country already equals if it does not exceed the power generated by solid fuel, or steam engines, and the end is by no means in sight. Motor trucks and farm tractors, delivery vehicles and pleasure cars are

on the increase to such an extent that in the year past the consumption of gasoline exceeded the yield. The problem of keeping the supply ahead of the demand is already shaping itself as a definite question which must be answered in the near future.

Take another illustration: W. R. Ormandy, writing in the London Gas World for August, 1914, states "The advantages of oil over coal as a source of power for many purposes, but particularly for naval purposes have lately been so vigorously canvassed and so exhaustively discussed by engineering experts, that there is now no purpose in dilating upon them * * * it becomes much more pertinent at the moment to consider what resources we have for securing our supplies at home * * *. Public attention has been directed to the possibility of producing oils for the Navy from bituminous coal, shale, peat, or even sewage matter".

Our own Secretary of the Navy in a recent article in one of our super-popular prints has stated that the stoker force required to shovel coal on one of the great ocean liners is 275 men, and where oil is substituted the crew for the corresponding work drops to 17 or practically 6 per cent; that the steaming range with a given fuel capacity is practically doubled and the time between ports reduced by 25 per cent.

These are only a few instances which might be multiplied indefinitely. The fact is that oil as a fuel for power purposes, whether we like it or not, is here to stay and we are fast approachng the necessity of finding augmented supplies.

As for the use of gas as a fuel, we are destined to see even more revolutionary changes. Coal burned under a steam generator may deliver say 12 per cent of its power in the form of effective work. A gas engine may deliver 30 per cent of its heat in the form of work, a margin much more than enough to pay the toll of converting the solid fuel into the gas form, leaving a generous surplus of efficiency for the gas produced from a given unit of solid fuel.

René Masse, a French fuel authority, writing in Chemie and Industrie for 1918 (page 665) proposes a plan for conserving the coal resources of France by gasifying the entire production, recovering the by-products and utilizing the gas and tar oils in engines for the production of electric power, placing all the plants under centralized control at stations located at the mines. Note that this is a conservation measure and is not prompted primarily as might be supposed from an artistic or sanitary motive.

Here is another reference of the same import. Samuel Wellington, writing in the London Gas World for 1919 (page 405) says "From the analysis of thermal efficiencies given there is every attraction for the consideration of the claims of gas as a profitable process in the conservation of coal for whatever purpose it is required." Indeed, we are even now coming around to the point where it is in place to brush off the dust of time and burnish up the statement of Sir William Siemens, made in a lecture delivered in 1881, which reads as follows: "I am bold enough to go so far as to say that raw coal should not be used as a fuel for any purpose whatever, and that the first step toward the judicious and economic production of heat is the gas retort or gas producer, in which coal is converted either entirely into gas or into gas and coke".

Have you ever stopped to figure some of our extravagances along these lines? The annual output of pig iron in the United States for 1916-1917 was approximately 40,000,000 tons. This called for 40,000,000 tons of coke, 50 per cent of which was made in ovens of the beehive type which either burn the volatile gases or send them off as waste into the air. The sum of this waste per annum amounts to approximately 300 billion cubic feet, equivalent to ½ of the total natural gas output of the entire country.

But, we need not go so far from home for a horrible example. Of the coal mined annually in Illinois, approximately 25,000,000 tons are burned in domestic appliances, and something less than that amount in factories and in-

dustrial establishments, not including the railroads. Now, if the inventors of domestic heating appliances had set out to assemble an inefficient lot of devices, they could hardly have surpassed their present accomplishment. They are especially effective in distilling off the volatile constituents of the fuel in the most suitable form. I use the word advisedly and with a deformed spelling. I mean to say, therefore, they are the most suitable forms for smudging up the flues and passageways of the stove or heater and all creation outside when the products of combustion and *non*-combustion leave the chimney. The factories may make a good deal of smoke, the evidence of it is pronounced, but in the aggregate the domestic chimneys are the worst offenders. They work over-time, even 24 hours in the day. If they ever slumber or sleep that is the very stage of their highest effectiveness in the matter of smoke and soot production.

Now, as a matter of fact, the kitchen stove or the basement furnace is doing as well as can be expected. It has not the white hot fire or the mechanical stoker or the extended combustion chamber of the factory furnace, and indeed never can approach those conditions which in the well-appointed manufacturing establishment burns its coal with the minimum amount of smoke, and so we come back to our starting point, namely, the purpose which seems the logical course, to provide from Ilinois coals a fuel which has had the smoke producing constituents removed. Constituents which may be worth only 5 cents as fuel, but probably worth 5 dollars in some other form. If this result can be made to work out in a practical way, as well as the laboratory accomplishments would seem to indicate, the work will have been well worth the doing.

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## THE IRWIN EXPEDITION ABOUT CERRO DE PASCO AND LAKE TITICACA

William Ray Allen, University of Illinois

In a recent number of "Science" Prof. C. H. Eigenman[1] gave a general outline of the Irwin Expedition of

[1] Science, August 1, 1919.

Indiana University to South America. The writer was a member of the party as a traveling fellow of the University of Illinois.[2] My chief activities were the collection of parasitic material, and the collection of the fishes of the Lake Titicaca basin.

All members of the party reached Lima, Peru, in August, 1918. As related by Prof. Eigenmann we followed up the course of the Rimac, and the upper portion of the Mantaro and its tributaries which center at Oroya.

As an introductory procedure I worked about Lake Junin in Central Peru and spent more than a month along the Huallaga from its sources near 14,000, feet down to 2000 feet.

After early September the writer proceeded independently of the others, first to Lake Junin and the Rio Huallaga, later to Lake Titicaca. Lake Junin (Chinchaycocha) is a shallow, mud-bottomed lake near Cerro de Pasco. It is surrounded by great areas of marsh and lies in the midst of an extensive peaty pampa at more than 13,500 feet elevation. It forms the source of the Rio Mantaro, one of the principal tributaries of the Ucayali, and this in turn one of the three chief Peruvian affluents of the Amazon. The inhabitants regard it as the true source of the Amazon an honor it shares with a score of high Andean rivers.

The pampa is a bleak area upon which virtually nothing grows except certain native sessile rosette-plants, representing a number of families, but principally composites. These constitute the pasturage of the few sheep and llamas that can be maintained. Everywhere in the Peruvian Andes there is a remarkable climatic difference between elevations of 12,000 and those of 13,500 feet. Though Lake Titicaca is five hundred miles farther from the equator than Junin, there, at 12,500 feet, an extensive agriculture is practised. Wheat, barley, and potatoes are rarely seen at elevations of 13,000 and the Junin pampa will produce none of them. At midday tempera-

[2] Special acknowledgement is due Pres. E. J. James, Dean David Kinley, and Prof. Henry B. Ward of that institution. It was only through their active interest and financial co-operation that the writer was enabled to be one of the party.

tures may be quite high. But nights are always cold, and the passing of a cloud over the face of the sun will cause the fisherman to assume his coat. In equal altitude at Cebollar, Chile, a diurnal temperature variation of 65° F. was encountered.

While the elevation is too great to allow more than a few land plants, there is still an abundance of aquatic vegetation. The lake bottom is deeply covered with mud and flocculent organic debris. Ceratophyllum, Potamogeton, and Philotria are abundant. The exposed roots of the shore plants at the water's edge are covered with great quantities of green fresh-water sponge, of which adequate collections were made.

The fish are of only two species, but very numerous in individuals. They are: the *bagre,* a Pygidium, catfish, which the inhabitants say ascends the rivers to spawn; and the *challhua,* an Orestias.

The fish are only slightly susceptible to dynamiting. It affected only those nearest the explosion. Most of these instead of rising to the surface as was expected sank into the ooze at the bottom and were lost. At first one is inclined to attribute this to the great elevation, and the decrease of about two-fifths of the atmospheric pressure. But the fishes here are apparently in as perfect adjustment to the existing hydrostatic pressure as at any other elevation, and ought therefore to respond in a similar way. It was disconcerting to cruise (in a motor launch kindly loaned by an American gun club at La Fundición) among the reedy embayments and lagoons, seeing vast numbers of fish in the clear water, unable to interest them in hook and line, unable to manipulate a seine, or to dynamite successfully, and the fish always out of reach of a dip net. The Peruvian came to the rescue. With a hardihood inherent in the dwellers of the bleak pampas he stepped into the water to his thighs, supporting his weight upon the rhizomes and roots of plants. Here he searched among stems for the fishes lurking there, and found them.

Very large frogs, Cyclorhamphus culeus Garman, were found fairly abundant in the lake and its tributaries.

They were much parasitized, especially with small Cestodes. The frogs are taken by the native *balseros* with a crude, three-tined gig, and are marketed at Junin. This species is not commonly used for food about Lake Titicaca, where it exists in great numbers.

The marshes and reedy islands surrounding Lake Junin harbor a multitude of birds, especially ducks, coots, and grebes. Seldom may one look out upon the lake without sighting the smoke of fires in the bulrushes employed by the Indians to reveal the nests of birds. The eggs are a highly prized addition to the scanty diet, though scorched by the fire or in a state of partial incubation.

Six weeks were spent upon the Huallaga river and some of its affluents. The highway from Cerro de Pasco to Huánuco follows the river from its origin, a group of springs below Cerro at 14,000 feet. Between Cerro and Huánuco, a distance of seventy miles, both river and road descend to an elevation of 6,000. In its upper course the river is mostly a series of rapids. No fish were encountered above Ambo, at an elevation of probably 7,500. They are said to occur at San Rafael during the lower stages of the river. This village has an elevation of 9,000 or more. At Huánuco several species of fish occur.

Collecting was continued seventy miles below Huánuco —as far as the Cayumba rapids, at 1,800 or 2,000 feet. These constitute an effective barrier to the tropical fishes of the lower course of the Huallaga. Not more than six species occur above the rapids. A native river man was able to enumerate and describe thirty-six species occurring from Cayumba to Tingo Maria, the ensuing forty miles. A crab was found for some distance above the falls, as well as below.

On the ridge of Punta de Esperanza, altitude 9,000 feet, and thirty miles northeast of Huánuco, the trail abruptly enters the tropical forest, which from this point onward entirely envelops the mountains. On the forested east slope the rainy season was well under way, in sharp-

est contrast with the barren west slope and ranges back of it.

Comparatively few of the mountain slopes have been cleared and placed under cultivation (chiefly to coca.) At San Juan, one of the estates of Dr. Augusto Durand, the writer was hospitably sheltered for ten days while engaged in collecting the parasites of tropical birds.

After certain delays due to transportation and to fever, work was begun in southern Peru in mid-November. The ensuing four months were devoted to the Titicaca-Poopó basin of Peru and Bolivia, and to northern Chile.

A few small fishes, Orestias, were obtained at Crucero Alto, on the Pacific-Titicaca divide above Arequipa, at an elevation of 14,650 feet. A narrow pampa forms an easy gradation here between the two slopes. The fish were collected from a network of sluggish ditches beside the railroad, and partially filled with ice and melting snow. In the Titicaca basin collecting was done at Lagunillas and Saracocha, lakes at about 13,500 feet, and in the Rio de Lampa at Maravillas and Juliaca. Similarly collecting was carried up the Rio de Pucará to Tirapata and La Raya, the latter on the Titicaca-Vilcanota divide at 14,150 feet. No fish occur in the swift water of the upper R. de Pucará, nor in the little sacred lake at La Raya. But *suches* (Pygidium rivulatum) were taken just over the divide, both in Lago Verde at equal altitude with La Raya, one kilometer north of the latter, and at Aguas Calientes in the upper river Vilcanota. The latter is a stream of the Urubamba-Ucayli-Amazon system.

For want of riding animals four trips were taken on foot, aggregating 200 miles, in order to reach some of the rivers and lakes of the Titicaca-Poopó basin. The first trip was from Puno to Yunguyo, paralleling the west shore of Titicaca. Collections were obtained at Puno, Chucuito, and Yunguyo from the lake itself, from the rivers of Ilave and Juli, and from the wet meadows of the pampa at Acora, Ilave, etc.

The second trip extended from the port of Moho, at the northeast corner of the lake, northwestward to Tirapata.

Collections were made in Lake Titicaca at Moho and Vilque Chico; in the meadow ponds of Huancané; the R. de Huacané, Lake Arapa, R. de Chupa, R. de Azángaro, and R. Porque. Laguna Salinas is too saline for fishes. In fact nothing living was found in it except certain phyllopod crustacea, Artemia salina (reported for the first time from the continent, though found in all other continents). These were very abundant, and in all stages of development simultaneously. Flamingoes were feeding constantly in the lake.

Lake Umayo, five leagues inland from Puno, is very rich in several species of Orestias. It abounds also in freshwater sponges, which form masses covering the roots of aquatic plants and exposed bowlders to a depth of one-fourth inch or more. Thanks to the hospitality and cooperation of Sr. Francisco P. Valcarcel I was able to obtain excellent collections there, and to visit the ruins of Silustani and Atunorco.

On the Bolivian side of Lake Titicaca fishes were obtained at Puerta Acosta and Guaqui. The Rio de Tiahuanácu was fished near the ruined "House of the Sun" at Tiahuanácu, and the Rio Colorado near Viacha.

La Paz marks the upper limit to which Atlantic drainage has invaded the pampas of the Titicaca-Poopó basin. Unfortunately the only fish obtained here turned out to have been introduced artificially from the Pacific slope near Mollendo. It is doubtful whether native fish ever reach this elevation, 12,000 feet, in the River Chuquiapo. The current is very rapid and the water polluted with sewage

Near Calacoto the Rio de Calacoto, R. de Corocoro, and R. Desaguadero were fished. The last is the outlet of Lake Titicaca into Lake Poopó. Since it is retarded here in a narrow gorge, there is great seasonal variation in the level of the lake above—as much as five feet between extremes.

Other tributaries of Lake Poopó visited were: R. de Eucaliptus, R. de Poopó, R. de Pazna, R. de Challapata, all to the east; southward, Rio Mulato and Rio Grande de Lipez.

Lake Poopó at 12,000 feet elevation in the Bolivian highlands, is nearly unapproachable, hence there is a total lack of native facilities, and it was possible to do shallow water fishing only. The lake shores are extremely flat. The fluctuations in level carry the shore line back and forth more than a mile from season to season. The writer was able to wade more than a mile out into the lake at its lower level before reaching water that was above the knees. In addition to the seasonal fluctuations there are changes in level of shorter periods, apparently almost diurnal. They are probably due to the wind rather than to the existence of a *seiche*. Though more than fifty miles long, and half as wide, the lake has a maximum known depth of but thirteen feet.

The literature is flatly contradictory as to the salinity of the water of Lake Poopó. It is in fact quite salt and non-potable. However the writer and attendant were able to subsist four days upon strong tea made with it. So far as observed the salt has no effect upon the fish fauna. The Rio de Juli in Peru is considerably more saline, yet is inhabited by the same fish as the adjacent freshwater creeks. Even Lake Titicaca is slightly salt, at least locally. This is not evident to the taste in most places. Some rivers of the altiplane are extremely saline and have no fish. Such are those about Urora, Bolivia, which thus resemble Laguna Salinas mentioned above. Other rivers vary seasonally in salt content. R. de Lampa in the rainy season has no taste of salt. But Mr. F. H. Grundy reports that at Maravillas during the dry season the Indians scrape salt off the rocks of its bed. Lake Poopó is probably less salt than it would be did its surplus not overflow annually into the Salar of Coipasa. Here, at Laguna Salinas, and elsewhere salt is recovered on a commercial scale by leaching it out of salty earth.

In the Rio de Poopó occurs a spring of superheated steam and water. This water mingles with and is gradually tempered by the water of the river. Small *suches* were observed in water of considerably more than 100° F. The same phenomenon occurs at Aguas Calientes in southern Peru.

At the same altitude as the Titicaca-Poopó altiplane the socalled Lake Ascotan is hemmed off by a ring of extinct volcanoes (only Ollagüe being active.) It is about twenty-five miles in extent and lies just within the border of Chile. It consists for the greater part of muddy deposits of lime salts. Numerous pools and sluggish streams appear throughout, and drain away by seepage. At the bases of the volcanoes along the eastward margin are many warm and cold springs. These are only slightly brackish. Small Orestias are everywhere abundant here, though there is no communication with the outside. Great quantities of aquatic plants of the same species as those found in other lakes occur. Facilities and help in fishing were kindly provided by Mr. E. W. Lycett, manager of the Borax Consolidated Company's calcining works.

Between Ascotan and the coast at Antofagasta lie vast volcanic areas and the nitrate belt. Only one river which might support fish occurs—the Loa. But at Calama (elevation 7,000 feet) it was found to be totally devod of them. This is reported to be due to a water fall twenty-five kilometers downstream, below which coastal forms exist.

No new genera of fish were obtained in the Titicaca-Poopó drainage system. Only two genera, Orestias and Pygidium, occur. There is probably sufficient material collected for adjusting the very unsatisfactory status of the species.

It is hoped that the parasites of the fishes may, through their affinities, throw some additional light upon the origin of the fauna of the land-locked Titicaca-Poopó system. With one exception few parasites were obtained from the many hundreds of fish dissected. The one exception was a minute, active trematode resident in the cranical cavity of nearly every Orestias examined, but not occurring in Pygidium. It is found not only in Titicaca itself but in all the tributary lakes and streams.

In the lakes of the altiplane the great quantity of bird life in the broad plant zone of the littoral is noteworthy. There are many coots, cormorants, grebes, ducks, flamingoes, ibises, lapwings, and gulls. The writer estimated that there were not fewer than 10,000 wading birds per

mile of the shore at the southern end of Lake Poopó According to F. M. Chapman they are principally winter residents. Many birds were found to be parasizited by tapeworms and Acanthocephali.

The lack of game fishes is much lamented both by the people of the country and by the English and American residents of the altiplane—principally employes of the mining companies. They regard the clear, cold, swift Mantaro and other rivers as well suited to trout production. Mr. A. S. Kalenborn of Oroya, and others, have made an effort, so far unsuccessfully, to procure from this country trout eggs or young.

In spite of the inferior quality of the native fish, the fishing industry is of considerable importance in Lake Titicaca. The chief Peruvian and Bolivian ports, Puno and Guaqui respectively, are noteworthy as fish markets. Many fish are shipped from these ports to La Paz and Arequipa. The Rio Ramiz and its tributaries at the north and the Desaguadero at the south are fished for *suches*. *Suches* are also taken in the lake, and when properly prepared are better than the Orestias. But they are much less plentiful and more expensive, especially when twelve to fifteen inches in length. *Hispes* (an Orestias) are taken when about three inches in length and dried entire. In this state they are marketed at great distances—even at Cuzco and beyond—and are much prized by the lower classes.

The smaller Orestias, *hispe* and *carache*, sometimes occur in remarkable concentration, especially in the meadow ponds of the pampas. Frequently scores of them may be dipped up with a single swoop of the dipnet. Even a roadside sheep-washing pool, without outlet and very muddy, contained a multitude of isolated, pallid *carachitos*. In the same pools occur also vast numbers of small Dytiscid beetles. As a result of this concentration no fish was found which did not have the fins more or less abbreviated.

# PRESERVES OF NATURAL CONDITIONS[2]

BY VICTOR E. SHELFORD, UNIVERSITY OF ILLINOIS



## I. INTRODUCTION

A few years ago the writer was appointed chairman of a committee charged with the listing of all preserved and preservable areas of natural conditions in North America. The committee is composed of about twenty-five members scattered throughout the United States and Canada. The first work was to make the list and when this had made some progress, to agitate for the reservation of such important areas as demanded immediate attention. The whole problem of securing the preservation of areas which is one of the objects of the work is very complex. At the outset the committee felt the lack of any definite guides in carrying on the work. However, a certain amount of progress has been made and out of this progress we can distinguish certain high places.

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[1] The work of a Committee of the Ecological Society of America Edited in proof by the Academy's Committee on an Ecological Survey of the State.

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## II. SOME REASONS FOR PRESERVING NATURAL AREAS

### GENERAL REASONS

"To realize the greatest profit, therefore, from the plant and animal life of the national parks, their original balance should be maintained. Park areas should be conserved unmodified in the interest of research and natural history. For, as the settlement of the country progresses, and the original aspect of nature is altered, the parks will probably be the only areas unspoiled for scientific study, and this is of the more significance when we consider how far the scientific methods of investigating nature then obtaining will be in advance of those now applied to the same study."—J. GRINNELL.

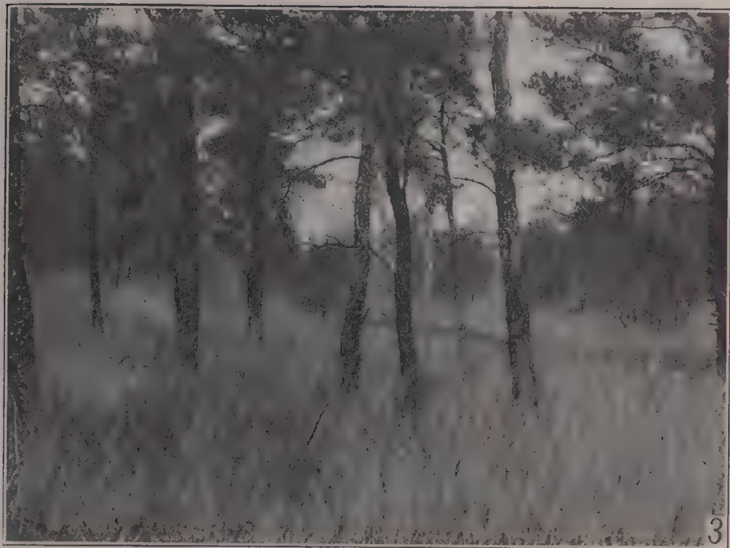
Among the recreative elements in nature the following are important: "First: either perfect quiet, or an absence of all save primitive and natural sounds, such as those caused by the wind in the trees, by running or falling water, or by singing birds. Second: landscapes that relieve the eyes from close work by offering distant views, quiet harmonies of color, and a quiescent atmosphere, varied by occasional touches of movement in such objects as running or falling water, scurrying squirrels, or birds in flight. Third: accessible mountains, which encourage climbing and allow the visitor to combine the exhilaration of overcoming obstacles with the physical exercise attending the woodsman's mode of travel. Fourth: natural phenomena that make a purely intellectual or esthetic appeal, as do the conflicts between the great insentient forces of nature, the processes of geological upbuilding and destruction, the intimate inter-relations of plants and animals, and the contentions for mastery that are forever recurring throughout the whole realm of living things. We believe the last, the mental appeal, to be the element of greatest recreative value in nature, but the other three are of only slightly less importance."—J. GRINNELL and T. I. STORER.

### IMPORTANCE OF EARLY ACTION

"After civilization has developed in any area, every one realizes the desirability of parks and reservations

1. The dunes at the head of Lake Michigan, looking west, taken fifteen years ago, showing land now held at an enormous price, which at that time had reverted to the state for taxes. Tall stacks and a cloud of smoke now stand out in such a view at the center of the picture, locating Gary, Ind.

2. Beach near Gary fifteen years ago. These areas are of immense interest to Illinois' most crowded population.




3. Early stage of forest development once common in northern Illinois and Indiana, now almost gone. This picture was taken on the site of Gary in 1905.


4. A later stage than that shown above, once common on the site of Chicago. Taken on the site of Gary in 1905.

5. Some of the oak woods in 1910 in a place similar to that shown in figure 4 showing needless destruction of vegetation.

6 and 7. Showing remnants of this vegetation along the main street of Gary in 1911.

which shall preserve something of the original conditions that existed before the advent of man, but in most cases it is already too late to secure the necessary action when the desirability of it becomes evident to most people. It is, on the other hand, extremely easy in many cases to secure reservations in unsettled country where there are no local interests to be interfered with by such action.

"The reservation of the Katmai National Monument in Alaska, which comprises some seventeen hundred square miles and is, next to the Yellowstone and Yosemite, the largest member of our National Park System, involved no difficulty whatever for the simple reason that it was carved out of an absolutely uninhabited country and there were no settlers on the ground whose interest could be interfered with by the withdrawal of the land from entry.

"The same situation obtained at the time of the creation of the Yellowstone Park, but now, when it is desired to extend the boundaries of the Yellowstone to include a considerable amount of country which it is universally admitted would be a highly desirable addition to the park, it requires much agitation and heavy expense to secure the requisite action because of the development of the country in the interim.

"The principal objection that is raised against the setting aside of areas in unsettled country is that they are in no danger of being disturbed by civilization and that therefore there is no occasion for their being reserved. In every case on record, however, history shows that the extension of civilization so far exceeds expectations that within a few decades at the most, the wilderness becomes peopled with a dense population and, where action was not taken in the early stages, it has become forever impossible to secure the parks of which everyone then recognizes the need.

"Any statesman-like view of the situation will convince one that the people who live in this country fifty years hence will be extremely grateful to this generation for every area it may succeed in having reserved, however

slight the present need of preservation may appear."—Robert Griggs.

Early action is always important, for the destruction of natural areas is continuous and progressive. Fifteen years ago the present site of Gary, Indiana, was public land, having reverted to the state for taxes. There was no particular reason why a considerable area could not have been reserved at that time by mere legislative act. The areas of dunes in northern Indiana are of immense importance to thousands of citizens of Chicago and other parts of Illinois; high schools, and two or three large universities need them for instruction in natural science, and they lie close at hand (see figures 1 and 2). Now however the land is held at an enormous price and the argument that reserves will interfere with commercial development has to be met. The Dunes National Park Association is striving to secure the reservation of some parts, but for considerable distances about each of the industrial centers the natural vegetation has been destroyed and no parks have been reserved by the municipalities concerned.

One who is interested in the preservation of an area usually wakes up to the fact that it is in immediate danger when the destruction is in progress and it is too late to stop it. Early action is the only effective kind of action.

### RECREATION AND PRESERVATION

"The most efficient means for preserving areas for study is by creating a lasting public interest in them and the public is interested mainly in that with which it most comes in contact. One cannot hope to be successful in a general policy of establishing preserves without developing an active public interest. Outside of material advantages, which have been so ably set forth, the chief public interest in preserves is, and will continue to be, a recreational interest. Interest, direct or indirect, in camping, hunting, and fishing is the greatest power available for establishing and maintaining preserves, for public interest is as necessary for the maintenance as for the establishment of preserves. As with life in general

few things have no disadvantages so in this case camping, hunting, and fishing seriously disturb the natural conditions of balance but the ecologist cannot afford to neglect to avail himself of this interest because of that fact. Most preserves must be established with this dual purpose of recreation and study and proper measures taken to allow the one and protect the other. One has only to consider the comparatively small number of preserves established at the present time which have not had the direct or indirect support of this recreational interest or the economic, to be convinced that where the one carries less force the other must be utilized."—G. W. GOLDSMITH.

THE AUTOMOBILE

"The automobile is fast opening up the most inaccessible sections of the country to the hunter and the industrial exploiter, as well as to every week-end excursionist who chances to own a 'tin Lizzie.' All are combining to destroy our native fauna and flora, and to upset the general balance which was maintained for ages before the entrance of man. Nearly every day's papers throughout the summer and fall, chronicle a considerable list of forest fires, most of which, according to wardens, are due to carelessness on the part of campers or hunters. But this list does not include the hundreds of square miles of brush and chaparral which are burned over every season."—F. B. SUMNER.

HEREDITY

"The science of ecology, for example, depends upon undisturbed patches of nature as its 'material.' More important still, all that we have learned of geographic distribution and geographic variation has come from the study of native species taken in their original habitats. This work is far from being practically completed throughout our country, as some may be inclined to think. For the genus Peromyscus, I am disposed to think that the real task has only *just begun*. I know that there are other biologists who believe, as I do, that the problems of heredity and evolution are not all to be solved by rear-

ing pedigree-cultures of the fruit-fly and evening-primrose. We must study the actual products of evolution as they have arisen *in nature.*

"The main thing is to recognize (as many biologists do at present) the need of concerted action, in order to save certain small fragments of living nature. Without this, we shall certainly lose the greater part of the material upon which our sciences of ecology, geographical distribution, taxonomy, etc., are based."—F. B. SUMNER.

### SUBSTITUTES FOR WOOD

"A favorite argument of those opposing forest conservation for their own ends is that when our valuable species are gone we will find substitutes, grown in a shorter time, and that 'this will involve no necessary impairment of public wealth.' Also, that steel, cement and other products will take the place of wood. This can be answered by saying that in spite of the increasing use of substitutes, the per capita consumption of wood goes right on increasing. The substitute is usually more expensive and not so satisfactory. Engineers have been trying for years to invent a satisfactory steel or cement railway tie, but have not been successful. Steel ties lack elasticity, are subject to damage by freezing and thawing, and are much harder on the rolling stock. Where can we find substitutes for hickory for spokes, ash for handles, and oak for ties and furniture? Why wait until these valuable species are exhausted? Let us rather conserve while we may the remaining supplies at the same time saving the industries dependent upon these species for their raw material."—R. B. MILLER.

### DOES IT PAY?

"I know that in this section of Canada (British Columbia) something more is required than is covered by the arguments submitted above. In the first place we have to show that it pays to have reserves. It has paid Switzerland, it has paid New Zealand, it has paid the United States, to set aside parks; the sums of money brought into those countries by visitors to those regions, are greater

8. Showing a piece of Illinois second growth with many seedlings indicating rapid forest reproduction.

9. A similar area pastured showing the complete destruction of seedlings of future forest trees.

than those expended in protecting the parks and making them accessible.

"Just as we preserve the works of great masters, and find that the longer we have preserved them, the greater their value becomes; so we are seeking to preserve the works of the greatest of Masters, and if length of time increases the value of these works they are infinitely more valuable than works of art. In this we appeal to almost all sections of the community. The economic aspect is dominant in our immediate vicinity. 'Will it pay?,' has been answered satisfactorily. They are attractive to the artist and poet as a source of inspiration; to the educator as a source of illustration; to students of geology, botany, physiography, etc., as a source of instruction; and to all as a source of health and recreation which leads one's thoughts away from the mundane affairs of this world 'Through Nature up to Nature's God.' "—John Davidson.

The ideas brought out here, as reasons for preserves, all include reasons why "it's paying." It pays to preserve forests and swamps as watershed protectors and flood preventers. It pays to educate the public in forest practice, fish culture, culture of water plants, etc.

### SIZE OF PRESERVES—LOCATION

"The Governor of Illinois stated that he was strongly in favor of rather large preserves, averaging say a thousand acres. He also said that these should be well distributed through the state so that all citizens in the state would take a large interest in the movement. My own personal feeling is that an effort should be made also to have preserves in proximity to each of the major population centers."—H. C. Cowles.

### EFFECT OF LUMBERING IN PRESERVES

"I am of opinion that from the point of view of ecological study, the result is unfavorable. That is to say, if it is desirable for that purpose that the occurrence and proportionate representation in the forest of the various elements of the vegetation should be exactly as

nature developed them, then any kind of lumber operation is bad. The opening up of the forest cover, and the cutting and destroying of certain species to the exclusion of others, is almost sure to encourage a type of vegetation not found before the forest was disturbed."—R. T. Fisher.

### GRAZING IN PRESERVES

"The sheep destroy the young trees and when the old ones die no forest will be left."—H. C. Cowles.

"I wish to urge that every side of the problem be considered before forest reserves and, particularly, national monuments, are opened for sheep grazing. In my natural history field work through the state I have had occasion to observe the disastrous results following upon close sheeping. These results are such as to leave the territory in many cases open to soil erosion and practical effacement of original conditions. Cattle grazing is not nearly so injurious.

"I have been fortunate in having spent three months in field work this year in the east-central part of California and western edge of Nevada. The only human industry affecting wild life there is grazing of sheep; for instance the White Mountains, in Mono County, are altogether too closely sheeped, with the result that the riparian and palustrian fauna and flora of the higher altitudes are almost completely tramped out. For example, a shrew was newly named from there in 1891. The intensive work of our party the past summer failed to find a single shrew. The near vicinity of the small streams, springs and seepages is now a mere dust wallow."—J. Grinnell.

Cattle are less serious but destroy the forest nevertheless. See Fig. 8-9.

### AQUATIC PRESERVES

"It is our belief that the preservation of marshes is a most important step. In so doing you will be providing an important nesting place for game birds rapidly being driven out by drainage of land, and a tract peopled with

small animals particularly suited for aquaria for public schools.

"Many swamps lie in the direct migration route of many species of birds which are used as food, or which destroy crop pests farther north. This is so important that through gifts and state acquisition Louisiana has set aside areas of swampy land along the southern coast to serve as way stations for migrating birds and as a breeding place for the native species. Thus, swamps have a real value from the standpoint of birds alone; they are not the only animals found in and about marshes, which provide us with necessities, including food, furs, buttons, and other articles. The marshes and water courses of Louisiana yield upward of $700,000 per year in products including turtles, frogs and furs.

"Upland marshes also have values similar to those of the lowland and coastal swamps, and an additional and important function. With the clearing off of timber and the draining of such swamps the streams appear to be subject to greater floods and to more extreme low water. The latter conditions in particular are important in connection with the effects of pollution. It is at extreme low stages that the streams are overloaded, and that a small amount of pollution overtaxes the self-purification mechanisms, with results almost as disastrous to fishes and similar animals, as if the low water occurred throughout the year.

"A part of any large swamp, such as the Okefinokee Swamp, or any other natural area is as valuable as the most expensive American museum, one which requires say $10,000,000 endowment and $500,000 annual expense. Such swamps are really museums of living things, the value of which at any time may become infinitely great in the solution of important scientific problems, which involve living animals. Each year animals and plants find new uses and new values. No one would have thought white rats, guinea pigs, and common mice worth saving a century ago; if the question of sacrificing all of them for a little additional land to cultivate had been raised it would have received but one answer, there would be none of these animals now. Yet by far the greater part of our

laws of immunity from disease, heredity of cancer, as well as of heredity in general have been, or are still being, worked out on them. The investment in equipment and salaries for such investigation amount to millions of dollars every year. Preserves of our native flora and fauna are more important than museums of dead animals. To quote a recent writer on water culture: 'We urge that water areas, adequate to our future needs for study and experiment, be set apart and forever kept free from the depredations of the exploiter and of the engineer.'

"The nation has preserved certain areas as national parks, national monuments, national forests, etc., for the use of the nation as a whole. The states have reserved some similar areas. The humblest citizen has a right to the recreation values of the bodies of water near his home, and his children should be able to wade in a nearby stream and pick up stones without danger to health. The day is past, even in America, when population is so small and resources so great that these general interests can be sacrificed for the profit of a small group of citizens."—V. E. Shelford.

## LITERATURE

When one reads such poems as Bryant's "Prairies," he wonders how future generations are to interpret his works.

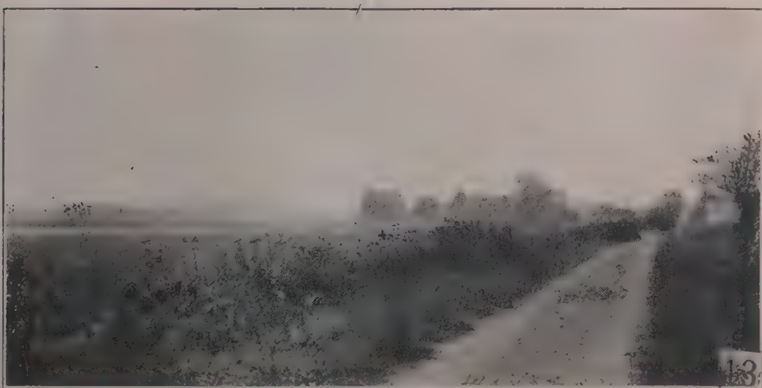
"These are the Gardens of the Desert, these
The unshorn fields, boundless and beautiful,
For which the speech of England has no name—
The Prairies. I behold them for the first,
And my heart swells, while the dilated sight
Takes in the encircling vastness.
The hand that built the firmament hath heaved
And smoothed these verdant swells, and sown
their slopes
With herbage, planted them with island
groves,
And hedged them round with forests. Fitting
floor
For this magnificent temple of the sky."

—*Bryant.*

10. Showing a typical prairie peninsula—surrounded by forest on three sides, characteristic of Illinois. Note forest edge of shrubs. (Riverside, Ill.)

11. Close view of low prairie-forest edge shrubs.


12. Close view of prairie amid forest groves (Riverside, Ill.)



13. Prairie plants in autumn, skirting a road side, with scattered trees in the distance—suggestive of the original condition in northern Illinois.

Where will students expect to find the source of the poet's inspiration?—V. E. SHELFORD.

See Figs. 10, 11, 12 and 13.

### III. COMBINATION OF INTERESTS

The work of the committee has shown further that there are many different groups with common interest in natural conditions. There are various state and national *forests* the primary purpose of which are to provide lumber under forest culture conditions. Some of these areas are large and would permit of a reservation of subdivisions for particular purposes. (1) Foresters themselves maintain what they call *sample plots* or small areas in which they have measured all the trees and taken a very complete census of woody plants. They propose to leave these small areas in their original condition and merely note the natural changes which take place in the forest. (2) Sportsmen, likewise, desire to increase the amount of game and in many states certain forest areas are set aside as *game sanctuaries.* In Pennsylvania a game sanctuary has a single wire stretched around it and is kept carefully guarded by wardens. No hunting is allowed inside the wire. The game is allowed to reproduce unmolested and overflows into the surrounding territory where hunting is permitted. The game in the areas is not likely to become very much more numerous under such conditions than it was originally with its natural enemies, such as wolves, etc, roaming about. Thus perhaps within the sanctuary the condition of balance of animal life is as nearly like the original one as could be hoped. (3) Ornithologists are interested in areas which afford a *protected nesting place* for a great many birds and (4) Wild-flower lovers desire to see the flowers preserved and accordingly are interested in natural areas which may act *as reserves and seeding centers.* (5) Artists and landscape gardeners wish beautiful spots of nature for *subject matter.* (6) Historians wish to know the character of the original vegetation for use in *interpreting history.* (7) Students of literature desire areas which may serve as a basis for *interpretation of past literature.* (See p. 46.) (8)

Biological investigators require reserves for investigations in ecology, general biology, zoology, botany. It is often possible for these several groups to combine and make a strong plea for the setting aside of areas bounded by natural topographic features as preserves of natural conditions to serve all the eight or more purposes enumerated. In addition to this there are often *water-sheds which supply water to cities* and water for *irrigation* purposes which will always be maintained and are available for sample plots, bird preserves, ecological study, and perhaps game sanctuaries. Forest practice retains some of the natural features. The combination with recreation interests is by no means impossible.

## IV. MANAGEMENT OF PRESERVES

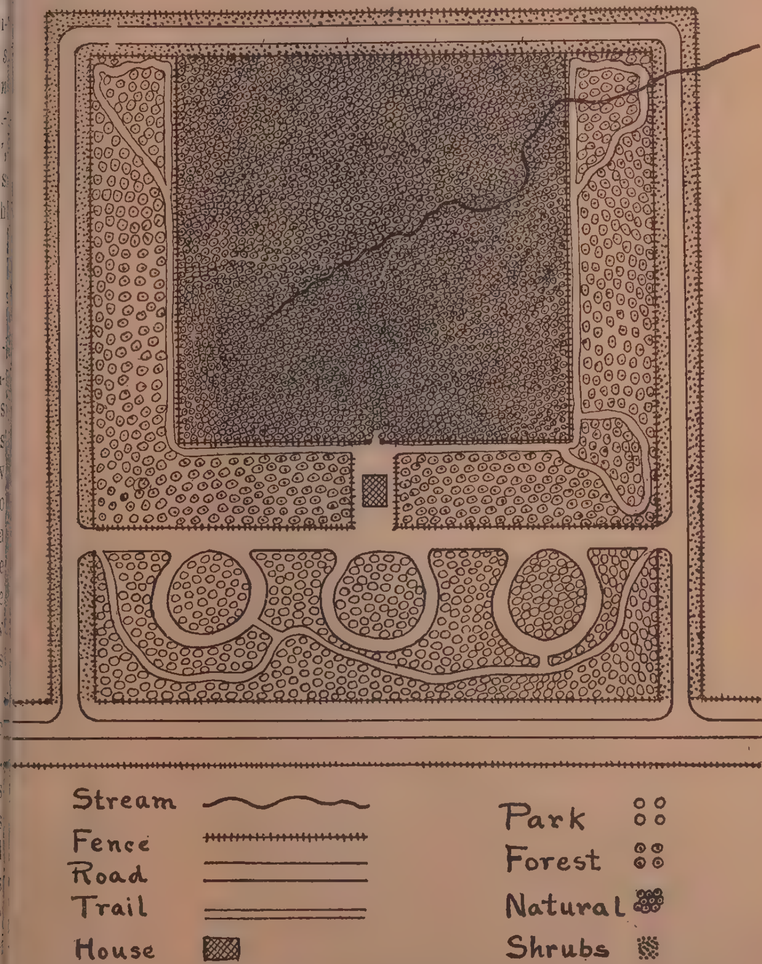
1. *Mismanagement.* In Illinois two types of mismanagement have been noted. The first amounts to no management at all; the public is merely excluded, some times an untrained guard is present and at other times he is not, resulting in offense to the public, and followed by opportunity for retaliation when he is not at hand. No removal of plants and animals is allowed except by a large flock of chickens from an adjoining farm yard. The closing of the woods has caused dissatisfaction to the public and injured the cause of preserves. A man may be only a skunk trapper but to exclude him from his trapping preserve is offensive and undesirable.

The second type consists of general disregard of the wild natural features. Automobile roads are cut through woods where only trails should be opened. No places are reserved for camping and recreation. The result is that the wild parts are destroyed. Exotic trees and shrubs are planted. Considerable areas are modified as golf courses. Cattle, sheep and goats are pastured in the preserves and forest reproduction prevented. Wild flowers are picked and rooted up and carried off. Care takers are untrained for their work, have no knowledge of sylviculture, etc.

2. *Management.* Each reserve should be roughly divided into recreation and preserve areas and in most

cases also some portion should be set aside for sylviculture or at least for demonstration work.

Figure 14 shows a plan for a 60 acre tract designed primarily for a preserve of natural conditions. The en-




14. Suggested management of a 60 acre tract of forest, combining a small forest park with three circles for lunch fires, an area for farm wood-lot forestry demonstration, an area of natural conditions, the entire area surrounded by a drive to serve as a fire break. The drive margins set with native forest edge shrubs and designed to serve as nesting sites for native birds.

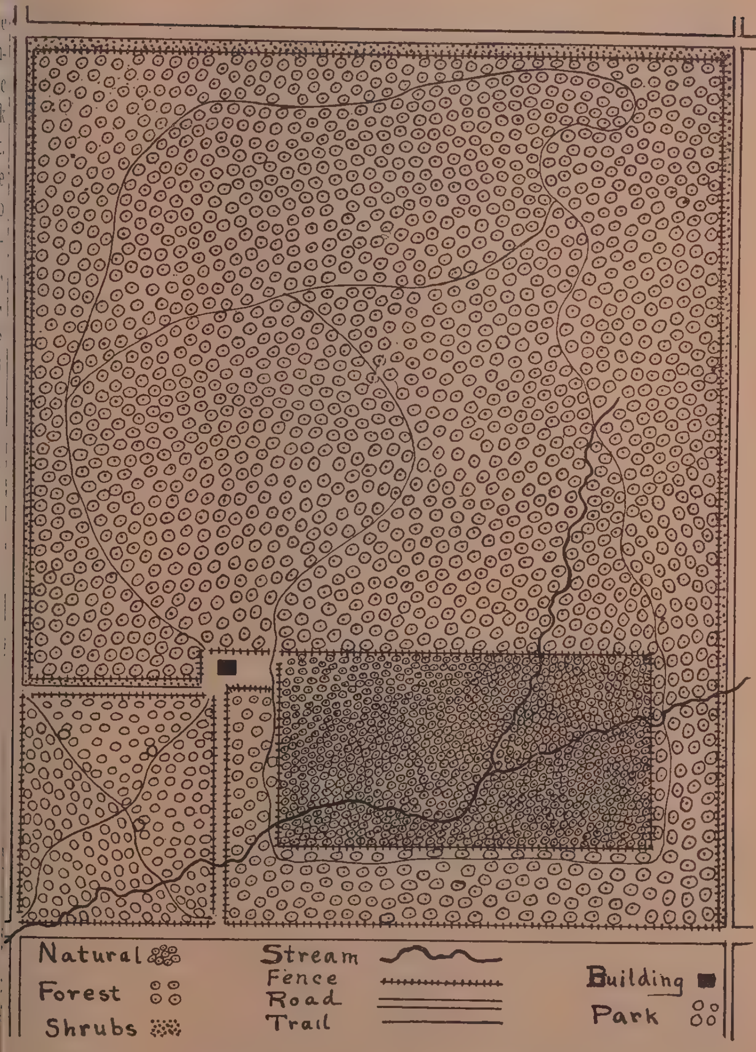
tire tract is surrounded by a drive to prevent fires. The drive margin is set with native shrubs such as grow at the edges of woods, etc. designed to attract a maximum number of birds. The front portion adjacent to the public highway containing about 14 acres is a public forest park with three circular drives within which fires may be built. Behind this are two areas (with the keeper's house at the center). The central area is a preserve open only to those with special interests and designed as a game sanctuary, wild flower center of seeding, a bird sanctuary, etc. Surrounding the central preserve area, is another, designed for sylviculture, the chief object of which is the demonstration of farm woodlot forestry. This is open to the public with some restrictions.

Figure 15 shows a similar plan for a 1,600 acre tract devoted primarily to sylviculture. The public forest park is in the lower left hand corner.

### V. METHODS OF SECURING RESERVATION OF AREAS

The nation, state, counties, or municipalities must own preserves. Nothing can ordinarily be done without public interest. Probably the best way to arouse it is by the organization of a local society having a particular preservation project as its sole or main object. For example a society known as the Okefinokee society was recently organized at Waycross, Georgia, for the express purpose of securing the preservation of Okefinokee swamp. This society has tried to interest various people throughout the United States in the project. It has two classes of members, those who pay larger or smaller contributions or dues for the support of publicity work and those who are called associate members who merely sign a pledge to support the project without paying dues.

An organization has been formed on the Pacific coast having for its object the preservation of an area of redwoods. Its name is Save-the-Redwoods League. They charge a fee to all members and accordingly have been a little less successful, perhaps, in enlisting a considerable body of men on account of the high cost of living and the rather high cost of membership.




15. Plan of management of a 1,600 acre tract to serve for the most part as a timber growing project. 120 acres is set aside as a public park for camping, hunting, etc. A somewhat larger tract serves as a natural preserve and a game sanctuary and is surrounded by a single wire. Such a tract will support a number of deer and in fact should have them to maintain a condition such as was originally present.

The Okefinokee Society has secured action in the Georgia legislature which memorialized Congress to make a national park of Okefinokee Swamp. At the last meeting of the American Association for the Advancement of Science both of these societies presented resolutions which were passed by several biological societies interested in these projects, asking the Council of the American Association to recommend the two preservation projects to the federal government officials. At the present time the National Research Council is in close touch with the federal government and in a position to get in touch with Congress. It is an additional body to which appeal may be made.

Preservation of areas by the state requires similar effort; similar general methods may be followed. But methods may be more direct as it is easier to reach state officials directly than the national officials and it is the states that have been especially interested in game sanctuaries and in some cases in bird preserves. Thus the people interested in preservation of natural conditions for purposes of study should undertake to get their project before the fish and game officials and the bird societies of the state.

Many states have state foresters who usually are interested in reserve projects and who often would be able to combine their sample plots with the proposed project for the preservation of natural conditions. In the state of Illinois, for example, a law in force for some years renders possible the formation of county forest preserves in counties with municipalities. The signatures of a body of citizens and the ruling of the county court favorable to the project following a hearing for objections, can automatically condemn a selected tract of woodland as a forest preserve, and bond the county to purchase the same to be paid for from a county mill tax provided for in the law. This method is probably not particularly valuable except near the large centers of population where the securing of the signatures is comparatively easy and preserves more appreciated than in the small communities.

Certainly in Illinois and in all other states there should be preserves of natural conditions in the vicinity of all the larger institutions of high rank. These are needed in connection with all the various biological courses but particularly forestry. Certainly they have a value in the interpretation of literature and art in a great many cases at least, and often as well in the understanding of history.

Doubtless in many cases the preservation of natural conditions may be combined with recreation projects, tracts may be provided which are in part in their natural state and in part made up of tree-covered pasture land such as the public desires for camping and picnics. The Cook County forest preserves are serving various purposes. It is probable that in the more thickly settled parts of the country no tract of forest will be in original condition; any considerable tract will contain some original stand, some second growth, some pastured area. The second growth is good for forestry purposes, the pastured areas particularly good for recreation, and the undisturbed situations particularly if they lie within these can easily contain certain sample plots of the forester and serve as game sanctuaries and bird preserves.

## VI. GENERAL PROBLEMS RELATED TO PRESERVES

These are (1) the preservation of portions of the original flora and fauna, in the semi-natural conditions accompanying agriculture, including (2) the preservation of the nesting sites of swamp birds, and of the swamp flora and fauna generally, also (3) the drawing of correct conclusions from the conflicting views of bird protectors, on the one hand and clean-culture agriculturalists and entomologists on the other. They are, however, closely related to the task with which we are concerned.

1. Clean-culture (roadside mowing; burning) vs. roadside and streamside shrubbery and bird and original life preservation. Birds are decreasing because of lack of nesting sites. Entomologists and some agriculturists maintain that this destruction is necessary to agriculture; while the bird men insist that birds are also essen-

tial. The practice in the United States should be ascertained; the areas in which specially destructive and drastic measures such as burning are necessary, should be clearly defined and limited.

2. Upland marshes are important water-storage sponges letting it out slowly during dry seasons thus controlling floods. Such marshes are gradually being drained and the flood menace is increasing every year. The only way to save these natural resources and at the same time the swamp faunas, especially the birds, is to utilize the swamps for aquiculture. To this end several aquicultural experiment stations should be established.

For the present there should be one perhaps at Cornell University to deal with upland marsh problems. There should be another in connection with Okefinokee Swamp and one in connection with the coastal swamps of New Jersey. In addition to frogs, fish, and birds, a number of plants are good for food, etc.; cattail flour and cattail paper have recently been tried with success. Swamp potatoes, the corms of arrowhead, and seeds, roots and stalks of our native lotus served as food for the American aborigines and pioneers. Hedrick (Science 40: 611), Claussen (Sci. Mo. 9:179), and Needham and Lloyd ("Life of Inland Waters") have discussed these questions and are actively interested.

## VII. DESCRIPTIONS OF NATURAL AREAS

A listing of all preserves and preservable areas now in a natural condition constitutes an inventory of what has been done and what may still be done. The list, now incomplete but in tentative form, indicates that there are certain kinds of areas of which we have no preserved samples or no areas proposed for preservation. For example, certain types of semi-desert have attracted so little attention that there is a possibility of none of the type of vegetation which they represent being preserved. The list also shows that there are many preserved areas of certain types and very few or none of others, and that the territory near educational institutions which can make use of such preserves, in many cases, is almost

without any facilities such as reserves afford. Thus the general list serves to give us an idea of what should be done in the way of securing the preservation of additional areas.

It is desirable that State Academies gather all possible information relative to preserved and preservable areas in their respective states. This does not need to be of the nature of an accurate survey. So long as the size and location of the tracts are approximate and the general character of the vegetation is known, the tracts can be about as well described as the limits of printing descriptions will permit. It will be well for academies to print lists of areas suitable for ecological and other biological study and related to the various interests enumerated on page 47 and circulate them among the people of the state.

The Ecological Society of America desires to publish a National and International list of Areas suitable for biological study, etc., and will appreciate securing copies of these descriptions. This society desires to publish the list covering all of North America and South America to the Equator which is the territory being visited by American scientists at the present time. A general plan for uniform descriptions and descriptive terms has been worked out and is indicated below.

### 1. *Preserved Areas. Model Description*

The description below is offered as a model for those describing areas.

Riverside Flood Plain and Savanna Forest[1] in the Cook County Forest Preserve. About 20 acres along the Desplaines River; typical mature flood plain forest of maple, elm, basswood, walnut and oak—shows succession from middle age to mature stage. Forest edge with sinuate outlines, outlying groves; grass covered portions, typical mesophytic prairie; general aspect characteristic

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Figures in ft. indicate elevation above sea level.
† Especially important; should be preserved unmodified.
‖ Hotel or boarding house during touring season only.
§ Camp outfit desirable; ** camp outfit necessary.

of large areas in Illinois oak grove savanna.[7] See Bryant's poem "The Prairies." The fauna of the forest edge is especially characteristic; in the forest, raccoons, gray squirrels, and many characteristic invertebrates. Stream badly polluted. 630-650 ft.; level (See Figs. 10 to 13).

Chicago[8], 12 miles west, C. B. & Q. R. R. or La Grange Electric; ½ mi. N. W. from (w) Riverside, Ill. John Doe.

Name each preserve according to a locally known point, as a village, river, mountain or the like, and the natural ecological features.

The model would be preceded by a general description of the Cook County Forest Preserves. Describe general areas first; for example a National Forest, and follow it by the descriptions of important natural areas within it accompanied by the phrase e. g. "in the Teton National Forest".

The first name of a town or city following the description is the nearest station at which through trains stop, the nearest town with good hotel accommodations, or the like; where practicable the town should be large enough to be on available small scale maps and serve as a catch word for location. It is followed by the distance and direction *to* the locality's nearest postoffice with name of transportation routes available; after this follows the distance and direction *from* the nearest postoffice which is given last followed by the state or province, and finally the name of the person describing the area.

Letters in parentheses preceding the name of the nearest post office indicate desirable means of reaching the area as follows: (w) on foot; (a) by automobile; (h) horse back.

The following types of conditions have been recognized. The first twenty with the possible exception of the S. E. conifer forest are believed to be dependent upon climate. The last four or five are known as local or edaphic or microclimatic conditions.

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[7] Refers to numbered paragraphs describing large communities which appear in the main to be dependent upon climate.

[8] Hotel or boarding house facilities.

1. Tundra or Barren Grounds (Arctic of Merriam); Northern part of the continent, in N. E. United States during glacial times.

2. Northern Conifer Forest (Canadian and Hudsonian of Merriam except in the Pacific slope area); Northern United States and Canada, extending southward into the mountains where it has been designated as Mountain Conifer Forest.

3. The Northwestern Moist Conifer Forest (Vancouveran of VanDyke); Pacific slope Northern California to Alaska.

4. Semi-desert Conifer Forest; on the western desert mountain slopes and foothills.

5. Poplar Savanna; a narrow strip skirting the conifer forest on the south and west; Wisconsin to Alberta.

6. Deciduous Forest; Eastern United States and Southern Canada.

7. Oak Grove Savanna; Mississippi Valley,—Illinois was originally of this type. (See Figs. 10-13).

8. Southeastern Conifer Forest; S. E. United States, near the coast.

9. Grassland and Steppe; the Great plains.

10. Temperate Semi-desert Broken Steppe; the Snake River Valley, Northern Texas, and portions of New Mexico.

11. Mexican Plateau Desert; the Chihuahua-Zacatecas area in Mexico.

12. Extreme Desert (small leafed shrub desert); Lower Colorado River Area.

13. Sage Brush Desert; the Great Basin.

14. Eastern Succulent Desert; West Texas.

15. Western Small tree and Succulent Desert; Arizona and Sonora.

16. Mesquite Semi-desert; Southern Texas and N. E. Mexico.

17. Broad-Leafed Evergreen Semi-Desert (Californian of Van Dyke); California.

18. Temperate Rain Forest; possibly the "Hammocks" of Florida and some mountain sides in Mexico.

19. Tropical Rain Forest; S. E. Tip of Florida (?), West Indies and portions of Mexico and Central America.

20. Tropical Deciduous Forest; portions of Mexico, West Indies and South America.

21. Alpine Summits; chiefly in the western states, and Mexico.

22. Lakes, ponds, and streams;

Designate streams as "torrential"; "swift"; "moderate"; "sluggish" or intermittent; give your estimate of width and depth at mean low water.

Designate ponds and lakes as "young" with much terrigenous bottom; middle aged with little terrigenous bottom; or old with no terrigenous bottom, etc.

23. Swamps and marshes.

24. Marine shallows and embayments.

25. Sand areas, talus slopes and gravel slides.

Designate topography as "level"; "rolling"; "sharp"; "precipitous"; "badlands"; "dissected"; i. e. comparatively level and cut by many deep ravines. Terms such as mountain, hill, level plain, ravine, canyon, bluff, shore, and sandy, rocky, glacial floodplain, etc. are used.

The agency which owns, and controls, and manages the preserve should be given. Any matters which need attention, such as lack of management or mismanagement should be mentioned.

2. *Proposed Preserves.* The description of these should be similar to that of the preserved areas but uses which the preserve will serve should be given, the population centers, schools, colleges, museums and societies which can make use of it should be stated.

# GAINING AND LOSING POWER

Casper L. Redfield, Chicago, Ill.

A man goes into a gymnasium and takes up physical training. The first day he gets tired very quickly. The second day is the same, and the third day and the fourth day. But if he continues, there soon comes a day when he can exercise longer and harder without becoming so tired. And if he keeps on day after day, and month after month, he finds he continually gains in his capability of withstanding severe exercise without weariness.

When a man who has been leading an active life changes to a sedentary one he finds, after a few months, that he has lost something of that energy, vim, pep, which he had before, and that he tires more quickly than when he was active. If his sedentary life continues year after year, he finds that his physical powers continually decline.

What is this thing which is gained by exercise and lost by idleness? What are the conditions under which there is a change from gain to loss or the reverse? How long will gain in powers continue to follow exercise and loss of powers follow idleness? What are the limits of gain and loss? Can an animal by continual exercise become more powerful than any ancestor? To how many different organs does this kind of gain or loss apply?

The object here is to bring together some of the facts which will help to furnish answers to these questions. The facts bearing upon this matter are to be found in many and diverse places, but we will consider only such as lend themselves most readily to scientific exactness, or are most convenient for illustration.

Of all animals, the trotting horse has been more regularly and continuously trained for the purpose of producing physical development than any other, and the mile track and stop watch furnish scientifically exact means for measuring the gain coming from exercise. It is universally recognized that powers continue to develop during growth, but it is generally believed, and sometimes stated, that such development ceases when the ani-

mal becomes full grown, or soon thereafter. The horse is full grown at three or four years of age, consequently we will look at what occurs under continuous training after full growth.

HIGHEST SPEED OF FLORA TEMPLE AT DIFFERENT AGES

ONE MILE

| | |
|---|---|
| Five years old | 2:49 |
| Seven years old | 2:36 |
| Eight years old | 2:27 |
| Eleven years old | 2:24½ |
| Fourteen years old | 2:19¾ |

Flora Temple was not raced as a six-year-old, but was trained and raced every other year up to sixteen years of age. She continued to gain in trotting power under continued training up to fourteen years of age, though the gain was not uniform. At sixteen she nearly equalled her best previous record, but her racing career was suddenly terminated by Government action. That was in 1861.

By continually exercising the powers she had, Flora Temple acquired powers she did not have before, and powers which never existed in any ancestor. By her own efforts she acquired powers beyond her inheritance, because no previous horse was capable of trotting as fast as she trotted, and she could not inherit from ancestors a power which the ancestors did not have. As an eleven-year-old she trotted faster than any previous horse had trotted, and as a fourteen-year-old she broke the world's record four times in succession. Whenever a horse becomes a champion trotter, the fact that he does become a champion is of itself positive evidence that he has greater trotting power than he inherited—greater power than existed in any ancestor, or in any relative of any ancestor. During the past seventy-five years there have been more than twenty such horses to become champions, and no matter how good a horse may be, he can become a champion only as the result of many years of strenuous efforts. He must acquire by his own efforts that which he did not have, and that which never before existed.

## HIGHEST SPEED OF GOLDSMITH MAID AT DIFFERENT AGES

ONE MILE

| | |
|---|---|
| Eight years old | 2:36 |
| Nine years old | 2:30 |
| Ten years old | 2:24½ |
| Eleven years old | 2:22½ |
| Twelve years old | 2:19½ |
| Fourteen years old | 2:17 |
| Fifteen years old | 2:16¾ |
| Sixteen years old | 2:16 |
| Seventeen years old | 2:14 |

When Goldsmith Maid trotted a mile in 2:17 as a fourteen-year-old she broke the world's record, and thus demonstrated that she had developed more trotting power than ever existed in any previous horse. As a fifteen-year-old she broke the record again, and then once more as a sixteen-year-old. As a seventeen-year-old she broke the record four times in succession. By continually exercising the powers she had, she continued to gain in trotting power from youth to old age, and made the most striking gains in the evening of life. The powers she developed in that way greatly exceeded anything which ever existed in any ancestor.

It is not often that horses are trained continuously for so many years as were Flora Temple and Goldsmith Maid, but for the purpose of showing that the results obtained were not due to something peculiar in the inheritance of those animals, note the fact that during 1917 more than one hundred trotters, ranging from ten to fifteen years of age, made faster records on the race tracks of the United States than they ever made before.

## HOLSTEIN-FRIESIAN MILK PRODUCTION

SEVEN-DAY OFFICIAL TESTS

| Average Age. | Pounds of Milk |
|---|---|
| Two years and two months | 322.7 |
| Three years and two months | 400.3 |
| Four years and two months | 446.8 |
| Six years and six months | 450.7 |
| Seven years and seven months | 472.6 |
| Eight years and three months | 499.8 |
| Nine years and seven months | 564.8 |

The first part of this table is just as it is furnished by the Holstein-Friesian Association for 1913. The second part is a tabulation made from the records of 1906. The reason why it was necessary to make this tabulation is because the association does not classify cows over five years of age, but lumps them all together.

The cow reproduces before two years of age, and is full grown at three. As further evidence that milk-producing power continues to develop under milk-producing exercise long after full growth, take note of the average amount of milk produced by the 1,497 Jersey cows of all ages tested during 1916.

JERSEY COW MILK PRODUCTION

YEAR RECORDS. OFFICIAL TESTS. 1916.

| Ages at Calving | Pounds of Milk |
|---|---|
| Under two years | 6242.2 |
| Two years to three years | 6710.0 |
| Three years to four years | 7317.1 |
| Four years to five years | 8040.2 |
| Five years to six years | 8255.0 |
| Six years to seven years | 8340.2 |
| Seven years to eight years | 8702.2 |
| Eight years to nine years | 8667.0 |
| Nine years to ten years | 8643.3 |
| Over ten years | 8900.0 |

The Binet system recognizes the continued development of mental power in human beings during the growing period, but let us go beyond that into the older life. It requires mental power to learn anything, and to retain it in memory while learning a second thing. It requires more power to remember two things while learning a third; still more to remember three things while learning a fourth; more yet to remember four things while learning a fifth; and so indefinitely. As a matter of fact we carry more and more in our memory as the years go by, and the increasing load we carry is a measure of our increasing mental power. Even those persons designated as feeble-minded carry more and more in their memories as they grow older, and that fact is conclusive evidence

that they do increase in mental power, statements to the contrary notwithstanding.

The "dope fiend" will take a quantity of poison large enough to kill several men who are not accustomed to taking it. The man who survives the taking of such large doses does not do so because he was born with greater powers of resistance to that drug than other men. He does so because he began with small doses, such as any man might take and survive, and then gradually built up his powers of resistance by continually exercising them. By exercising the powers he has, a man can build up powers he did not have before, and powers which never existed in any ancestor.

By beginning with small doses and gradually increasing them, pigeons have been made resistant to rattlesnake poison. Resistance has been built up in this way until pigeons were able to withstand a dose more than four times as powerful as that which would kill in the first place. By exercising the feeble powers which they had, these pigeons acquired powers which they did not have before, and powers which never existed in any ancestor.

Let us turn aside and consider the powers of plants, because the matter under consideration is something fundamental in living things. If we take some wild plant and attempt to reproduce it by cuttings, we are likely to find that it can be reproduced that way only with difficulty. But if we take a cutting from the first plant raised that way we find the second time it grows a little more readily. If we take a cutting from the second plant to raise a third, we again find it starts more easily, and so on time after time. By many repetitions the plant develops the power of producing roots abundantly from cuttings. By exercising the powers which it has it acquires powers which it did not have before, and powers which never existed in any ancestor.

There is no selection in this matter. No seeds are produced. The final plant is really a developed section of the original plant, but has powers which the original plant did not have. A large number of our greenhouse plants

are now produced by cuttings, but originally came from stock which would grow that way only with difficulty.

All plants raised for any considerable length of time by division, like tubers, bulbs, cuttings, buds or grafts, gain the power to produce roots abundantly, and at the same time they lose the power, sooner or later, to produce seeds. By continually exerting themselves along particular lines plants develop new powers along those lines, and by continued idleness along other lines (seed production) they lose the powers they originally had.

In a wild state plants have to fight for existence in a world covered with other plants. When man domesticated certain plants he protected them from weeds. As a consequence of not having to fight for room against other plants, our domesticated kinds have lost the power of so fighting, and are unable to maintain themselves when deserted by man. Idleness along that line caused a loss of power on that line. There is no selection in this. Man did not select plants because of their inability to protect themselves.

Plants produce seeds. To casual observation, a seed looks like a dead object, but it came from a living plant and it has life. In that life there is the power of sprouting and growing into a new plant like that from which the seed came. But let the seed lie idle for one, two, three or more years, and that power gradually declines and finally ceases to exist. The loss of power due to idleness extends to the seed stage, and continued loss of power means loss of life. In the seed, life and power are one and the same.

Flagellata are protozoa which multiply by division. Dallinger subjected these animals to heat and found them dying at 74 degrees, Fahr. But by beginning at 60 degrees and gradually increasing the temperature he finally got them to stand 158 degrees without dying. Several years were required to accomplish that result. There was no selection in this. The final animals were simply divisions from the original ones. By continually exercising the powers they had, they acquired powers they did not have before.

Corn is sensitive to climatic changes, and can endure only slight changes without suffering seriously. But by moving it a short distance northward each year, it is now fully acclimated in regions where it was impossible to raise it forty years ago. Corn goes through the seed stage; flagellata do not. But each of them by continually exerting the powers they had, acquired powers of resisting temperature changes which they did not have before. The presence or absence of a seed stage does not affect the matter except as to the rate at which the acquirement occurs. The acquirement comes as a direct result of exercising the powers in existence. When the matter extends over several generations, the seed stage simply inserts idle periods during which there is no acquirement.

The blood reaction of different animals is different. With this in mind, let us consider some phenomena relating to vaccination. If we inoculate a cow with smallpox virus we remove the germ from a place where it was able to live to a new place where it meets a new blood reaction. Only occasionally does the germ survive in this new place, but when it does survive we may pass it on from cow to cow without difficulty. If, after passing the germ through ten or more cows in series, we take this virus and inoculate a man, we find that it is cowpox and not smallpox. A man so inoculated becomes immune to smallpox.

Going back to what we have learned about power being developed by exercise and lost by idleness, and applying that information to the facts just given about smallpox and cowpox, we can get some new light on the phenomena relating to vaccination. When smallpox virus is inoculated into a cow it will "take" only when it comes to some cow more susceptable than others. The germ in fighting for its own existence in a new blood reaction develops its powers of meeting that kind of blood reaction so that when it later is passed on to another cow it finds no difficulty in surviving in a place where before it could not have survived. In passing along from cow to cow these germs continue to develop their powers of meeting the blood reaction of cows. But while they are doing

this they are removed from the blood reaction of human beings, and because they are not fighting this particular blood reaction they gradually lose the power of fighting it. As a consequence, when they are later removed from the cow to the man they have only the powers of cowpox.

From these facts it will be seen that cowpox and smallpox are two strains of the same thing. One strain has its powers developed to meet the blood reaction of cows but not that of man, while the other has its powers developed to meet the blood reaction of man but not that of cows. Also, that either can be transformed into the other by a course of training designed to develop one form of power and not the other.

About 1880 Pasteur discovered that the anthrax bacillus cultivated in chicken broth at blood temperature lost its virulence after a few generations and ceased to kill even the mouse. Since then it has been learned that the virulence of many organisms became diminished when they are grown on artificial media. Let us consider what these facts mean.

When bacteria in small numbers get into the blood they are rapidly killed off. As far as we are at present concerned we need not stop to inquire whether this is by phagocytosis, chemiotaxis, or other means, or several means combined. The point here is that animal powers of some kind attack the bacteria, and for these bacteria to withstand these powers and make headway against them, the bacterial powers must be developed by exercise.

Now, when bacteria are raised on some nonliving substance, as chicken broth, they do not have to struggle for existence against a blood reaction and consequently they lose the power of meeting such reaction. A stallfed bacterium may be as fat as any other, but he does not develop individual powers any more than does a stallfed steer.

When a person exerts himself by physical efforts, he does certain foot-pounds of work, and foot-pounds of work is something well known in physical science. It is properly called "energy", but is referred to as "power" when we wish to indicate energy as being expended, or

capable of being expended. This energy which is expended by efforts comes out of the body of the person who exerts himself, and as we cannot get something out of nothing, the energy must be stored in the body of the person before he can do foot-pounds of work. If the efforts which a person makes are moderate, within the ordinary meaning of that term, then the foot-pounds of energy withdrawn by exercise are soon replaced by other foot-pounds of energy derived from food. The condition under which this results in a building process is one in which the amount of energy withdrawn from the system, in some unit of time, as a day, week or month, shall be a little less, but not much less, than the system can replenish in the same time from the food supply.

But it is known that by great efforts long continued a man may cause his own death as a result of nothing else than his own exertions. This means that death is caused by withdrawing from the system more than a certain amount of energy, and that in turn means that life itself is a form of energy. We identify electricity as being a form of energy, even though we do not know precisely what this form is. In the same way we can identify life as being a form of energy, even though we are unable to determine the essential nature of this form as distinguished from other forms.

We have identified life as being a form of energy by showing that life may be withdrawn from an individual by withdrawing foot-pounds of energy, and not withdrawing anything else. Likewise, life may be withdrawn from an individual by exposure to cold which results in withdrawing heat units, and not withdrawing anything else. As heat units are a form of energy, we again identify life as being nothing else than a form of common mechanical energy.

By the examples given it has been shown that powers are developed by exercising them, and the powers so developed are nothing else than stores of energy which are transformable into foot-pounds of work. By referring to the records of the trotting horse it is learned that those horses which had their powers developed (stores of en-

ergy increased) by training and racing live longer than do their untrained brothers and sisters who did not have their stores of energy augmented by special exercise. Here is a third identification of life itself being a form of common mechanical energy. Those horses live longest which have stored in their systems by acquirement the greatest number of foot-pounds of energy.

Women produce children, and in doing so they exercise many bodily organs not exercised by women who produce no children. Such exercise builds up energy in the exercised organs just the same as other exercise builds up energy in other organs. Statistics gathered by Cattell and by Bell show that those women who build the greatest amount of energy into their systems by this process before they are forty-five, are the ones who live the greatest number of years after they are forty-five. Here again we identify life as being a form of energy by showing that increase of energy means increase of life, and that we may build onto our inheritance by our own efforts.

Longevity is that power within the organism which prolongs life, and is known to be an inherited thing. In trotters, the offspring of those horses which have their powers developed by training and racing live longer than do the offspring of their untrained relatives. In human beings, when healthy women develop their bodily powers by producing many children, the later born children live longer than do the earlier born ones. The first of these items is taken from records published in The Horse World of Buffalo. The second is from statistics I gathered from genealogies. Both identify life as being energy; both make it clear that we can add to our lives by our own efforts; and both show that what is built up in that way is carried over by heredity to the next generation.

# REPORT ON THE PROGRESS AND CONDITION OF THE ILLINOIS STATE MUSEUM

February, 1920

A. R. Crook, State Museum, Springfield

The Illinois State Academy of Science is the logical body to whom an annual report should be made on the condition and progress of the Illinois State Museum, since the Academy is composed of men from all portions of the State, connected with all kinds of educational institutions, representing a great variety of occupations, and interested in all branches of science, and since the purpose of the museum is to present in concrete form all kinds of scientific knowledge for the use of all people of the State. Four out of five of the men composing the museum Board of Advisers are now members of the Academy. The Academy has from time to time made its influence felt by resolutions and by personal work on behalf of the museum. The first meeting of the Academy was held 1907 under the auspices of the museum. The financial relationship of the two institutions is intimate. And finally there is no body of men in the State more competent to pass judgment on the work of the museum than are the members of the State Academy. Hence this report.

The first and most important item of progress to be noted is the work on the new building. After many years of urging the need of a new building and of involuntary "watchful waiting" a magnificent new structure is being erected just south of the State House. The top floor of this building 270 feet long by 68 feet wide, commodious and well lighted, has been assigned to the museum, and it is thought that it will be ready for occupancy next year. It is realized that as soon as the building is completed various departments now waiting for quarters will pour into the building like sand through a sieve and hence it is very important that the musuem have ready exhibits which may in a measure block out the space assigned, be worthy of their surroundings and convey some concep-

tion of the wealth of the fauna, the flora and the mineral resources of the State.

During the past few years there has been a substantial growth of our museum materials in many lines both by gift, purchase and collecting in the field.

The collections of invertebrate paleontology numbering more than 30,000 specimens, which have been in storage for many years, are being worked over and put in shape by Mr. A. W. Slocom of the University of Chicago and Dr. A. F. Foerste of Dayton, Ohio.

The mineral collections have been greatly increased until now about 50 per cent of the commonly known minerals are represented, some of them by handsome specimens, some by many pounds of material, and some by minute examples. A case 15 feet long, 3 feet deep, 10 feet high has just been filled with Illinois mineral products of major importance. A "Guide to the Mineral Collections in the Illinois State Museum," forming a book of some 300 pages, is in the hands of the printer at the University of Chicago Press.

Minor advances have been made in conchology, entomology, ichthyology, herpetology and ornithology. The ornithological collections now contain most of the species of Illinois birds and there are six handsome groups with transparent backgrounds and one group of wild turkeys.

Two cases have recently been placed in the entrance hall containing casts showing the development of the horse in North America as worked out by Prof. Osborn of the American Museum and others, and of the human race, from the time of the Pithecanthropus to the Cro-magnon man as represented by skulls found, in many places by various anthropologists and by busts prepared by Prof. J. H. McGregor.

The general plan being followed in the museum is to present Illinois materials chiefly, and when expenditures are made to do a few things well rather than many things. As the result of this plan a number of groups have been completed and others are in preparation. The deer group, with which many of the members of the Academy are familiar has been followed by the completion of

two noteworthy groups and by work on two additional groups. The bear group occupies a case 14 by 20 feet and 18 feet high. The circular background painted by Mr. Chas. A. Corwin depicts one of the canyons in Starved Rock Park. Four bears, a male, female and two cubs, occupy the foreground. Mr. Julius Friessr, head taxidermist at the Field Museum made the group.

The Indian group, made possible by the generosity of Mr. J. W. Bunn, represents an incident in the life of the Sacs-Fox Indians one hundred years ago on the banks of the Illinois river where Peoria now stands. In the foreground are arranged seven figures—two warriors returning with a captive, a chief seated by the fire putting on his mocasins, a boy with bow and arrow in hand, a maiden standing by the door of a bark wigwam within which an old woman looks up only long enough to glance at the prisoner and then resume the pounding of corn in a log serving as a mortar. The figures were cast from life at an Indian reservation in New York and are therefore correct anthropological records. The trees, vines, hawks, arrowpoints and axes of Indian manufacture, the fire; the path winding over the hill; and the Illinois river and bluffs at the Narrows, skillfully painted on the curved canvass background, present a very pleasing picture. Both the picture, figures and foreground are the work of Henri Marchand, a one time student of August Rodin and Jerome in Paris. It is thought that this group is unsurpassed by any similar group in the country in ethnographical and artistic merit.

Two other groups are in preparation; an elk group and a mushroom group. Mr. Frank H. Connor of Chicago sent a party of hunters to Wyoming in November last and they secured six handsome elk. The skins are now being prepared. They will be displayed in a case 28 feet long, 16 feet deep and 18 feet high.

The most pretentious group thus far undertaken in the museum is one which will be completed it is hoped by May 1st. It will occupy a circular case with a background 60 feet long and extending to the ceiling. The observer entering the door comes into a small hexagonal

room 12 feet in diameter. The foreground from six to nine feet in depth merges into the panorama on the canvass. On the left is a wood, on the right brush, in front is a valley. An actual stream of water trickles from a spring and flows into the river. Appropriately placed in the foreground are more than two hundred characteristic Illinois mushrooms, made in wax and plaster. They are so skilfully wrought that it is almost impossible to distinguish the models from the original mushrooms. Doubtless in no other place is there a mushroom group of such artistic and scientific merit and it is our belief that this collection will be of practical as well as scientfic and artistic interest. This work was made possible by the generosity of Mr. J. W. Bunn and is being executed by Marchand. For nearly twenty years Mr. Marchand has been studying mushrooms and has made cast of many hundreds of species. Here are samples of four species—Amanita muscaria, Coprinus comatus, Galeria tenera and Sparassis crispa.

# Papers on Medicine, Public Health and Sanitation.

# SOME COMMENTS ON THE PRESENT STATUS OF TUBERCULOSIS

Walter Gelvin Bain, St. John's Hospital, Springfield

I believe that your Secretary was of the opinion that one's army experience must always give one some new ideas, when he asked me to appear before you with a paper. It certainly is the belief that I have acquired a clearer vision of the tuberculosis situation as a result of my army service, that leads me to comply with his request to read a paper on a subject which has been so much discussed and written about.

The greater part of my army service was spent at the U. S. Army General Hospital No. 8 at Otisville, N. Y., the seaboard hospital where the overseas chest cases were received and treated.

In general, my experience has given me a much more hopeful feeling toward the tuberculosis outlook than I had previous to entering the service.

I think that during the early months of our entrance into the war, the entire medical profession was much misled by the gloomy prophecies of our tuberculosis specialists. These men, basing their estimates on the reports of the Allied Countries, foretold the return of thousands of our American boys, victims of tuberculosis acquired in France. They pictured these victims scattering through our towns and villages, each a menace to his community, a carrier and spreader of the germs of the dreaded white plague.

It later appeared that the only basis for these false prophecies was the reports of the French on the situation in France. Particularly misleading was the report of Professor Landouzy, who first voiced this apprehension with his estimate of 150,000 cases of tuberculosis in the French army. This unfortunate exaggeration was widely quoted and quite generally accepted as representing the danger to French military efficiency from this source, and

by inference therefore, to the arms of the other nations as well.[1]

As a matter of fact, the later, more authentic reports on the French situation developed the fact that the number of soldiers discharged from the French army from August 2, 1914, to October 31, 1917,[2] was 89,430. Of these 70,196 were discharged previous to March 1, 1916, and largely represent pre-existent cases of tuberculosis caught into the army by the urgently rapid mobilization.

These cases constituted about 1.75 per cent. After these early cases were eliminated the percentage fell to .63 per cent, which is about the same as was later found in the Italian army where Sforga in charge of the diagnostic tuberculosis center of Rome, relates that the call to arms poured the entire male tuberculosis morbidity of the country into the army. Thus we were all led to believe that the high tuberculosis incidence among soldiers was due to the war, and that tuberculosis was rapidly increasing.

In the mobilization of the American army[3] the draft boards rejected 69,935 men for tuberculosis. The army surgeons afterward rejected 14,967 men who had been passed by the local draft boards, or a total of 84,903. It therefore appears that as the result of the careful medical examinations of our draft boards and army surgeons[4] tuberculosis was 13 times more prevalent among civilians than among soldiers. Instead of army life increasing the incidence of tuberculosis and returning our boys from France a menace to their communities, the army life really diminished the hazards from tuberculosis[5] so that

[1] Tuberculosis Among European Nations at War, by James Alexander Miller in the American Review of Tuberculosis, August, 1919.

[2] Tuberculosis Among European Nations at War, by James Alexander Miller in the American Review of Tuberculosis, August, 1919.

[3] The Present Status of Soldiers and Draft Rejects with Tuberculosis, by William H. Baldwin in the American Review of Tuberculosis, August, 1919.

[4] Victor C. Vaughn and George T. Palmer in The Journal of Laboratory and Clinical Medicine, July, 1919.

[5] Tuberculosis Among European Nations at War, by James Alexander Miller in the American Review of Tuberculosis, August, 1919.

The Army in Relation to the Tuberculosis Problem, by Col. G. E. Bushnell in J. A. M. A., June 15, 1918.

The Present Status of Soldiers and Draft Rejects with Tuberculosis, by William H. Baldwin, American Review of Tuberculosis, August, 1919.

whereas of the civilians applying for military service, 2.34 per cent were found tuberculous, only .05 per cent of those who came up for demoblization were found to have tuberculosis.

The facts that were to be learned from the examinations and care of some two thousand of these cases are the basis of my optimistic feeling toward the tuberculosis situation. These facts I will now discuss in a somewhat didactic manner.

### CAUSATIVE ORGANISMS

Although we handled a large amount of tuberculous material in the laboratory and our work naturally led us to constant review and perusal of recent literature on the subject, yet I am unable to note that the war developed any new facts relative to morphology, colony growth, motility, staining reactions or viability in vitro of the causative organism of tuberculosis.

As to the character of the toxin produced by this organism, the work of Vaughn,[6] wherein he identifies the various split products and determines their toxicity, appears to be the last and accepted facts of the situation.

### LIFE OF THE ORGANISM WITHIN THE HUMAN BODY

In a consideration of the organism and its probable entrance into the body, the burden of argument leads one to think that the tubercle bacillus finds its entrance into the human organism through the oral passage, rather than through the respiratory tract as I had formally believed. It may enter on food or in the food, or on the hands of the baby, soiled from the oral excreta of the adult carrier. Once within the oral passage, it possibly not infrequently finds its first point of localization in the tonsils.[7]

The paths of transmission from tissue to tissue in the body have been for a long time, as regards the tubercle

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[6] Protein Split Products in Relation to Immunity and Diseases, Vaughn, 1913. Chap. 8.

[7] Bacillus Tuberculosis in the Tonsils of Children Clinically Non-Tuberculous, R. S. Austin in American Journal of Diseases of Children, July, 1919.

Tuberculosis of the Ear, Throat and Nose, Arthur E. Prince and W. G. Bain, Illinois Medical Journal, September, 1910.

bacillus, a much debated question. A study of the relation of infected lymphatic glands to other localizations of the tubercle bacillus, is strongly convincing that the paths of transmission are by the way of the lymphatics, though, of course, there is the obvious transmission from one portion of an organ to another by contiguity.

### THE ANATOMICAL POINTS OF LOCALIZATION

Though it formerly had appeared that the tubercle bacillus might develop in any anatomical localization, the lungs being the most frequent location, it would now appear that the glandular tissue is primarily and most frequently involved.[8]

The bones and joints are involved secondarily in children. The apices of the lungs are involved most frequently in adults, our own autopsies showing the upper lobe more than 95 per cent, the middle lobe more than 80 per cent, and the lower left lobe slightly below 80 per cent, and more often involved than the right lower.

The effects of the growth of the tubercle bacillus on the infected tissues is a matter of greatest interest, in view of the fact that it is this particular phase of the situation upon which hinges the hopeful outlook for the future. It is the reactions to the primary lesion which must determine prognosis. The pathology, therefore, of the primary lesion, is all important. The following case cited by Dumas and Beclere[9] possibly throws some light on the character of the primary lesion.

"The breast fed infant of 13 month contracted tuberculosis from a nurse and developed spleno-pneumonic bacillaire with signs of tracheobronchial glandular involvement. The child threw it all off finally, and six years later not a trace can be found except one small shadow, evidently a calcified gland. This was probably the initial lesion, and around it was a perituberculous congestion so intense that it simulated pleurisy of the right side."

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[8] Deycke's Epidemiological Observations on the Occurrence of Tuberculosis in Turkey.

[9] Bulletins de la Societe Medical des Hopitaux, Paris.

Such a reaction occurs only in the individual who has no acquired immunity form previous tuberculous infection. These lesions, it appears from numerous authorities, occur in the infant under two years of age, and give rise, according to Hesse and others[10] to more deaths during the first year of life than any other period except between 35 and 40. This primary lesion occurs in one class of adults only, those who have been out of touch, from infancy, with civilization, with these it is particularly severe and often fatal.[11]

Romer, who reports on tuberculosis in Argentina and elsewhere, concludes that, "the less extensive the prevalence of tuberculosis in a population the greater the fatality of tuberculosis, or reversing the process, the more widespread tuberculosis is in a population, the less fatal is the form of the disease." In civilized communities the primary lesion does not occur in adults. The primary lesion is less fatal to infants, and the secondary lesion less fatal to adults.

It is the slowness of development of the secondary lesion and the reaction of the tissues to the toxins of the tubercle bacillus that convince one of the existence of a potential immunity. Statistics generally agree that the tuberculous lesion is found in more than 95 per cent of autopsies from deaths not tuberculous. These lesions show a calcareous center surrounded by a firm fibrous wall of tissue, and a third line of defense consisting of giant cells and endothelial leucocytes. It is this evidence that makes one certain that immunity can be developed.

On the other hand the remnants of defensive structures which are seen in the autopsies of those dead of tuberculosis give us additional evidence of this immunity. Here we find these walls of fibrous tissue, not of microscopical size, but in masses firm and solid, oftentimes thicker than one's hand.[12]

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[10] The Significance of Tuberculosis in Infants and Children, Alfred F. Hess, J. A. M. A. January 11, 1919.

[11] Review of Fulminating Tuberculosis of Tracheobronchial Glands, A. Dumas, J. A. M. A., June 7, 1919.

[12] Manifest Pulmonary Tuberculosis, Col. G. E. Bushnell, The Military Surgeon, April, 1918.

It is, in viewing such an autopsy that one feels that had the potential immunity been reinforced by the cooperation of the patient and community, the fight against the tubercle bacillus would have been won instead of lost.

### THE EFFECT OF THE TOXINS ON THE SYSTEM

Beside the local reactions above described, the toxins of the tubercle bacillus developing in an active lesion, have certain general effects upon the system. The toxins tend to bring about a depression of cell activity. This is manifested by the low white count frequently observed and recorded in our work, also by the general muscular weakness and low blood pressure. There is, too, a distinct singling out of the nervous system by these poisons which manifests itself in the reaction to stimuli of different kinds.[13] Advanced cases of tuberculosis show frequently mental weakness. These patients have erratic appetites. This may be due to the action of the toxin on the central nervous system or of tuberculous inflammation of the abdominal viscera. These tuberculous inflammations were present in a very large precentage of cases either as a tubercular involvement of the peritoneum, small intestines, the appendix, or cecum, or as a toxic cirrhosis of the liver.

### ATRIA OF EXIT

As to the atria of exit of the tubercle bacillus from tuberculous patients, the bacilli in the case of open lesions are undoubtedly constantly leaving the body in the feces. Occasionally we have found them in the urine. We always found them in the sputum in open lesions of the lungs, and in the discharges from pleural fistulae.

### MEANS OF DIAGNOSIS

From the standpoint of diagnosis the problem of tuberculosis was approached in at least five different ways. First, the application of the usual staining reactions to the sputum, by which means in open lesions one is usually able to determine the presence of tuberculosis positively.

[13] The Nervous System in the Tuberculous, A. Ferrannini in Riforma Medica, Naples.

So far as I could oberve in the making of thousands of examinations, the number of tubercle bacilli present bore no relation whatever to the physical condition of the patient. Thus if the tubercle bacilli were present in the sputum, the patient undoubtedly had tuberculosis. If the tubercle bacilli were not present, the burden of proof must then rest on the other means of diagnosis.

The second was the skin test of Von Pirquet, in which test, a small amount of Koch's old tuberculin is applied to a scarification of the skin, or by interdermic injections. This test was not used on tuberculous patients. However, some experimental work was done on healthy soldiers who volunteered, that we might determine the relation of a positive Von Pirquet to the normal individual. In these tests our observations were, that more than 95 per cent of adults give a positive reaction. There was considerable variation in the size and character of the reacting lesion, and the amount of tuberculin in a small percentage of cases had to be increased.

Two conclusions from these experiments could be drawn. First that the Von Pirquet has no diagnostic value in adults and second, the reaction is probably in proportion to the acquired immunity of the individual against the tubercle bacillus.[14] Spolverini applied this test to 900 supposedly non-tuberculous children under one year of age. He obtained a positive reaction in 7 per cent, .8 per cent positive at the age of four months, 4 per cent at six months, and the remainder, six to twelve months.

Third, the X-ray as a diagnostic means appeared to have much value, not, however, in determining an unrecognized tuberculosis, but in determining the extent of the lesion, its exact location, and its retraction under treatment when plates made at different periods were compared.

Roubier states in this connection on observation of a thousand cases of tuberculous suspects, that with an act-

[14] Observations which would have a bearing on the age at which the child began to acquire tuberculosis, by L. M. Spolverini in Rivista di Clinica Pediatrica, Florence, 1919.

ual tuberculous lesion at the apex[15] clinical and roentge findings harmonized in 90 per cent of the cases. Tl roentgen ray always revealed more extensive lesions tha would have been surmised otherwise. 4½ per cent we not diagnosed clinically but *were* diagnosed with the X ray.

The X-ray does not differentiate an active lesion fro an inactive.

Fourth, the use of the complement fixation test for tl diagnosis of tuberculosis was tried on a series of case with the result that it was only positive in cases of tube culosis. It was not positive in all cases of active tube culosis. It was negative in all normal individuals.[16]

Stoll summarized a number of cases in this connecti as follows: Forty robust men gave negative fixati tests. Of 161 of all kinds of cases, 45 were positive. our work we found that a higher percentage of positiv was observed when the anti-sheep haemolytic system w used instead of the anti-human.

Fifth, the determination of active tuberculosis a peared to rest finally upon the question of the presen or absence of moisture in the alveoli in the suspect tuberculous area. When at the end of expiration t separating of the moist walls of the tiny alveoli wi the resulting rale was heard upon auscultation, the ca was assumed to be one of active tuberculosis.[17]

## EPIDEMIOLOGY

A study of the tubercle bacillus outside of the bo has led us to believe that an organism in the bright su shine retained its ability to multiply for a minimu period of about six minutes. As the sunshine and lig are decreased and conditions of moisture are preserv it is supposed that the organism will live for days, wee or possibly months. Thus its presence in old houses,

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[15] A Thousand Cases of Tuberculous Suspects, reviewed by C. Roub Progres Medical, Paris, June 14, 1919.

[16] The Complement Fixation Test in the Diagnosis of Tuberculo Henry F. Stoll, J. A. M. A., April 12, 1919.

[17] Francis Trudeau in A. M. A. September 7, 1918.

Physical Examination in the Diagnosis of Early Pulmonary Tub culosis, by Louis V. Hamman.

the floor, in cracks, and rising in the dust, makes the organism a possible menace to the creeping infant, long after the carrier who left the organisms has gone from the premises, moved from the community, or died.

The organism on the other hand, may be transmitted to the child by inhaling the spray from the coughing tuberculous person, or by direct contact when the tuberculous fondle the uninfected child. The carrier of tubercle bacilli to the child may be without clinical evidence of tuberculosis. Some such lesion as a cavity communicating with the bronchus, frequently observed, may retain the bacillus for long periods of time. An adult in a high state of immunity to the tubercle bacillus may have a tuberculous tonsil or sinus from which the bacilli are excreted from time to time, and which local lesions are not of serious moment to the patent, but the excretions from which are capable of infecting the non-tuberculous child.

From what has been said it ought to be plain, that only infants from birth to two years are without tuberculous infections, except adults living away from civilized communities. These two classes of people then, are highly susceptible to tuberculous infection, originating outside of their own bodies. The adult in a civilized community acquires an active tuberculosis by a reactivation of an ancient tuberculous focus, which focus has been surrounded by a protective fibrous tissue wall, but which has been unable to prevent further dissemination, when the physical resistance of the individual remained lowered over a great period of time. It, to me, seems doubtful, in view of all of the evidence that has recently been brought to bear, that tuberculosis in the adult is ever acquired from association with the tuberculous.

What now are the lines along which the fight against tuberculosis is being directed? The measures adopted in the Army for the cure of the tuberculous soldier were, first and most important, and without exception, if the patient had an active lesion, to take complete rest in bed, night and day, week after week, until the moisture in the infected area had disappeared. During this period of

rest in bed, patients were given wholesome food an plenty of it. Their minds as far as possible, were pu at ease by allowing the patients to do whatever ment work was best suited to their mental capacity. If the were unable to read or write, one of the many faithful an self-sacrificing Red Cross volunteers was sent to the bedside where for hours, day after day, and week aft week, if necessary, these women would bring to bea every maternal instinct in order to keep the boys in contented state of mind. If the patients were able t use their hands and so desired, they were allowed to kni crochet, do basket work, draw, or work at some simila form of entertaining employment under the direction one of the corps of Reconstruction Aides.

Once a patient had reached a state of recovery tha classed him as a case without moisture or rales, he wa allowed to take part in one of the innumerable physic activities arranged for his benefit. These consisted everything from graduated marches to the regular wor in the shop, automobile department, or camp activitie The end and aim of all this treatment was to give th natural forces every chance, and to give every aid to th immune forces of the body to produce the ferments b which growth and extension of the tubercle bacillu could be checked. This alone was the specific treatmen for tuberculosis.[18]

Next, such protective measures as will separate th tuberculous with open lesions from contact with the uni fected infant, so that the infant will not at any time a quire a massive infection of tubercle bacilli from th excreta of the adult. For the protection of the adu against tuberculosis, there is primarily the maintainin of physical resistance, which resolves itself into the civ problem of housing, wages and conditions of work, an which makes incumbent upon you as free citizens, as Ot R. Reichel of the New York Board of Health express it, the following duties:

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[18] Manifest Pulmonary Tuberculosis, Col. G. E. Bushnell in The Mi tary Surgeon, April, 1918.

1. It is your duty to stop careless spitting. Public ntiment against this dirty habit must become so strong at nowhere will it be tolerated.

2. Do all in your power to keep the place in which ou live and work absolutely clean, and especially to revent dust.

3. Insist upon fresh air and sunlight at all times and all places; become a fanatic on the subject. Fresh-air natics are very badly needed. They are especially eeded on railroad trains, in drawing rooms, in many fices, and, alas, not only in many theatres but also in any lodges, clubs and churches.

4. Never occupy a new home until it has been thorughly cleaned and aired. Prefer places that have exposre to sunlight.

5. It is almost superfluous to add, keep clean in body nd mind, be moderate in all things; eat only plain, holesome food; drink and smoke in moderation or not all. It is best to abstain entirely.

6. Last of all, everything that you can do to make life ealthier and happier helps to avoid tuberculosis—better ages, better working hours, better food at lower prices, aygrounds for children and adults, better factories, hools, homes and work places. We can do no better han try to live healthy, happy and useful lives, and to ssume a strict personal responsibility, as is our civic uty in a republic, to see to it that opportunities for these ings are available to all the people, but especially to ose less fortunate in life than ourselves.

## STATISTICAL STUDY OF INFLUENZA IN ILLINOIS, FISCAL YEAR, JULY 1, 1918-JUNE 30, 1919

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In the year 1918 the death in the United States was the ghest in the experience of the Census Bureau. It was 3 per thousand. The preceding year the rate for the untry was 14.2. A study of the statistics showed that e excess mortality was practically confined to the last

three months of the year when a great epidemic of in-fluenza was raging. The excess in number of deaths du to influenza and pneumonia for the year was almos exactly equal to the excess in general mortality.

In speaking of the mortality rate for individual dis-eases it is customary to speak of the rate per 100,000 o population. During the year 1918 the rate in the Unite States was 298.9 for influenza, and 284.3 for pneumonia all forms. This rate is not as large as the rates whic will be given for the State of Illinois, but it must be re-membered that the year 1918 closed while the epidemi was in full sway. The statistics which are studied fo Illinois are for the fiscal year of the State beginning July 1, 1918 and closing June 30, 1919. These data fo the State of Illinois, therefore, cover the entire period o the epidemic.

For the annual report of the Department an estimat was made, county by county, of the cost of certain com-municable diseases. For influenza we estimated the cos of treatment for each case at $10 and the loss of time a $15. Each funeral was estimated at $100 and each lif lost was valued at $3,000. This very moderate estimat showed an economic loss in the State of Illinois of $73, 710,000, or an equivalent to a per capita loss of $11.59 t each resident of the state during the single year, 1918-19 The fact that a disease is communicable indicates tha theoretically it can be controlled; but to control it w must know the conditions favorable. Accordingly a spe cial study was undertaken relative to this disease in th State.

In making a statistical study of influenza in Illinois w must constantly bear in mind the sources of possibl error.

1. *Estimated population.* The Census in Illinois i taken on decennial years, and the population for inter mediate years is estimated according to previous growth Unusual development or decline in population is not ex pressed in these estimates. In other words the estimate population for any area may be falsely large or small.

2. *Errors in diagnosis.* Errors in diagnosis are common, and especially when the germ of a disease is not surely identified such errors cannot be guarded against. Under normal conditions the tendency is to fail to recognize such a disease as influenza at least in its milder cases, and so the reported cases would only be a fraction of the whole. On the other hand in the height of an epidemic and especially of a great pandemic the psychological effect results in calling anything approaching influenza in nature a genuine case. It is quite possible, then, that the reported cases would exceed the true number.

3. *Health authorities are often negligent in collecting and forwarding reports of communicable disease.* Thus in Pope County during the year studied there were reported less cases of influenza than there were deaths from the disease. Statistics based chiefly upon morbidity reports are therefore very misleading.

4. *Death Certificates.* In Death Certificates we are exposed to the same errors in diagnosis as for morbidity reports. In addition a large proportion of Illinois physicians do not make out their Death Certificates properly. Fatal influenza is almost invariably connected with pneumonia. The proper certificate should give influenza as the cause of death and pneumonia as the contributory cause or complication. This is not the arbitrary ruling of the State Department of Public Health; it is in accord with the rulings of the U. S. Census Bureau, and with the rules laid down by the international committee. Nevertheless, in one County Medical Society meeting, where the question was asked, fifteen out of the sixteen present said they would give pneumonia as the cause of death. In many of these certificates, although the real cause of death was influenza, there has been no mention of influenza as related to the case.

All certificates giving pneumonia or bronchopneumonia as the cause of death are questioned by our Department. It is the experience of the U. S. Bureau of Census, of our own Department and of other investigators that such questions result in a decided reduction in the number of deaths recorded for pneumonia and a corresponding in-

crease in the deaths assigned to other diseases. In fiv years experience of the Metropolitan Life Insuranc Company such investigation of deaths reported simpl for pneumonia resulted in a transference of 7.5 per cen to other causes.

In this study an estimate was first made of influenz alone, county by county through the State. When i seemed best to study the reports for cities it was foun that there had been such a transference of assigne cause from the pneumonias to influenza that the death in the city from influenza exceeded the total formerl given for the entire county.

The experience of statisticians in the study of influenz indicates that it is generally best to consider deaths as signed to the different forms of pneumonia with thos assigned to influenza. This was done in comparing th rates in the cities with those of the counties in which th cities were located. For the purpose of studying the dis tribution of the disease through the State we depende solely upon the records of influenza. In comparing citie with containing counties we compare the number o deaths from influenza and all the pneumonias with mor bidity reports only of influenza for the reason tha through most of the State cases of pneumonia are very imperfectly reported.

5. *There is another source of error in Death records* Some undertakers neglect to obtain burial permit promptly and it seems impossible to get some loca registrars to send in their reports each month. Thi negligence on the part of some registrars is assisted by the absolute failure of boards of county commissioner to provide for the payment of the fees which the Law de mands. Cook County Commissioners have never sinc the Law went into effect provided for the payment o registrars in the County. After the data were collecte for this study bunches of death certificates were receive from some local registrars which would have decidedly increased the mortality rate.* * *

* Since this paper was written Cook County has paid local registrars

* * * * The reported cases and deaths due to influenza were collected for each county and from these data we estimated the rate per 100,000 of population and the deaths per 1,000 of cases. We found that the average for the State was 3,517 cases and 396.6 deaths per 100,000 of population and the deaths were 112.7 per 1,000 cases. Dividing reported cases and deaths each into three classes we find nine possible combinations:—High mortality and high morbidity, high mortality and medium morbidity, high mortality and low morbidity, etc. Upon coloring the map of the state according to these nine classes we find the various colors are pretty evenly distributed through the State. Neither north nor south, east nor west shows any special color. Two counties, namely Pope and Schuyler, were given a distinctive color because their reports were manifestly unreliable. We do find that the populous centers and the coal mining areas show a large amount of the disease. The counties showing both high mortality and high morbidity are Lake, LaSalle, Grundy, Rock Island, Peoria, Champaign, Christian, Franklin, Perry and Union. Those showing low morbidity and low mortality are Carroll, Lee, Kendall, DuPage, Putnam, Stark, Cumberland, Clark, Clinton, Hamilton and Williamson.

It is easy to see that where the population is close together the opportunities for infection are more numerous; also where people are closely associated the chance is greater that the infective dose will be large. The indications are that the germ of influenza is conveyed through exhaled droplets. In crowded work rooms and in mines the chance is great that the air may be saturated with these germs if there be cases present. We are not surprised, therefore, that in crowded sections the cases should be numerous and severe, but Cook County, and especially Chicago, shows less mortality than Lake, La-Salle or Grundy, where the density of population is less. There must be some other important factor.

There are certain important general biologic laws which must be remembered. (a) When a germ is im-

planted in favorable soil, under favorable conditions it tends for a time to increase in virility.

(b) After the soil has been to a degree impoverished by any special strain of germ the growth will become weaker and more stunted.

(c) Germs, whether weak or strong, when transferred to an average soil tend to preserve their former character.

Most elderly persons by virtue of having had influenza in the epidemic of 1889 or later had therefore a degree of immunity to the germ. Young persons generally had a less degree of immunity because at the most they had been exposed to an attenuated form of the germ. The normal community is made up of both young and old, and its susceptibility to such a disease may therefore be considered as normal. A community made up chiefly of young people would theoretically have more than the normal degree of susceptibility to the disease, and would prove a favorable soil. We should therefore expect such a community to show high morbidity and high mortality. This is well represented in Lake County which contained a large Army Camp at Fort Sheridan, and the Great Lakes Naval Training Station. Champaign County contains a large university and the aviation field at Rantoul. There was a camp in Peoria County. On the other hand, communities which had lost an appreciable proportion of their young people, especially if they contained no important business interests which would attract large numbers of people, might reasonably be expected to show a lessened susceptibility. Though the disease might find many victims in such communities we should not expect a high death rate. In the main our study of the records for the State bears out these general conclusions, but we are struck with a marked exception. Winnebago County, containing the largest camp in the State at Rockford is classed as low in morbidity and average in mortality. When, however, we include the figures for the pneumonias we find that its morbidity total was very heavy. In most counties the deaths from pneumonia were recorded as less than those from influenza. In Winnebago the deaths

from pneumonia are four times as numerous as those from influenza.

A study of the map shows that though Chicago is medium in morbidity and medium in mortality the county outside of the city is high in number of cases but low in mortality. The low number of cases in the city may be misleading. It is not impossible that the cases were more fully reported in the surrounding area. However, we find a similar condition shown in Alexander County as compared with Cairo, in Macon County as compared with Decatur, in McLean County as compared with Bloomington, in Rock Island County as compared with Rock Island, in Tazewell County as compared with Pekin. It is very natural that the inhabitants of the surrounding area should get their infection at their County Seat. Their sickness would be at home and away from the germ laden air of the city. We find in Winnebago County a reversal of these conditions. The morbidity is higher in Rockford than in the county, according to report, but the mortality is more than ten times greater in the county. This is explained by the fact already mentioned that Camp Grant was located in the County outside the limits of the city, and its death rate was very great because it was made up of extremely susceptible material.

Returning now to the map of the state, attention is called to Calhoun County. This county is a ridge of high ground between the Mississippi and the Illinois Rivers. It is the only county in the State which is not touched by a railroad and it is not even served by an electric line. It contains no large town; the people are very largely farmers. Its isolated position and its rural character would lead one to expect that it would have few cases and that they would be of a mild nature. In fact we found that the cases reported were at the rate of 8,862 per 100,000, more than double the average for the State. The death rate however was 267.1 whereas the average for the State was 396.6. The large number of cases may have been the result of duplication of reports, because the reporting areas are not clearly defined. The small population of the county—8,610—makes it possible that a very

few double reports would be very misleading as each case would be at the rate of 100 per 100,000.

Comparing a map showing density of population of counties with the influenza map we see that density of population has apparently little direct relationship either with the incidence or fatality of influenza. Of the counties showing high incidence and high mortality only three have a population of over 90 to the square mile according to the 1910 census, namely, Lake, Rock Island and Peoria. Williamson County is high in population but low both in incidence and mortality from influenza. The mortality in Cook County from Influenza is medium, and there the population is most dense. The same is true of Madison and St. Clair Counties, which are also reckoned among the dense population. Carroll, Lee, Kendall, Stark, Putnam, Clark, Clinton and Hamilton Counties which are low both in incidence and mortality from influenza have a population of less than 45 to the square mile. Generally speaking the counties having a population less than 45 to the square mile show low mortality.

On looking over the death certificates one is struck with the large number of names which show Italian, or Slav nationality. This class of people generally live in crowded quarters which are poorly ventilated. We are lead to suspect that their great mortality is not due to their nationality per se but it is more likely to be the result of their environment and manner of living. This predominance of such foreign born among the deaths in mining communities may perhaps to some degree account for the increased mortality among miners. A special study was not made upon this point, but the suggestion is made more from a general knowledge of conditions.

STATE OF ILLINOIS

DEPARTMENT OF PUBLIC HEALTH

JANUARY, 1920

INFLUENZA, Illinois, Fiscal Year, July 1, 1918–June 30, 1919

| | Population | Reported Cases | Reported Deaths | Per 100.000 of Population. Cases | Per 100.000 of Population. Deaths | Deaths per 1,000 cases |
|---|---|---|---|---|---|---|
| STATE ........... | 6,359,102 | 223,683 | 25,222 | 3,517 | 396.6 | 112.7 |
| Adams ........... | 64,588 | 2,580 | 211 | M3,995 | M326.7 | 81.8 |
| Alexander ........ | 25,699 | 795 | 82 | M3.094 | M319.2 | 103.2 |
| Bond ............ | 17,949 | 418 | 57 | L2.330 | M317.7 | 136.3 |
| Boone ........... | 15,481 | 466 | 51 | M3,010 | M329.5 | 109.5 |

INFLUENZA, Illinois, Fiscal Year, July 1, 1918–June 30, 1919—Continued

| | Population | Reported Cases | Reported Deaths | Per 100,000 of Population Cases | Per 100,000 of Population Deaths | Deaths per 1,000 cases |
|---|---|---|---|---|---|---|
| Brown | 10,397 | 973 | 19 | H9,364 | L182.8 | 19.5 |
| Bureau | 46,934 | 2,931 | 148 | H6,245 | M315.3 | 50.5 |
| Calhoun | 8,610 | 763 | 23 | H8,862 | L267.1 | 30.1 |
| Carroll | 18,035 | 479 | 42 | L2,657 | L235.1 | 87.7 |
| Cass | 17,501 | 674 | 79 | M3,851 | H451.4 | 117.2 |
| Champaign | 55,539 | 3,314 | 231 | M5,968 | H416.0 | 69.7 |
| Christian | 35,309 | 1,768 | 167 | H5,008 | H473.1 | 94.5 |
| Clark | 23,517 | 559 | 68 | L2,378 | L289.2 | 121.6 |
| Clay | 18,661 | 954 | 57 | H5,113 | M307.9 | 59.7 |
| Clinton | 25,480 | 687 | 63 | L2,696 | L246.7 | 91.7 |
| Coles | 34,842 | 2,604 | 126 | H7,474 | M361.6 | 48.4 |
| Cook | 2,904,800 | 59,136 | 9,278 | L2,036 | M319.5 | 156.9 |
| Crawford | 32,490 | 1,427 | 76 | H4,392 | L233.9 | 53.3 |
| Cumberland | 14,281 | 198 | 40 | L1,386 | L280.1 | 202.0 |
| DeKalb | 34,953 | 1,236 | 115 | M3,536 | M329.0 | 93.0 |
| DeWitt | 18,906 | 1,350 | 77 | H7,143 | M407.4 | 57.0 |
| Douglas | 20,024 | 968 | 68 | H4,835 | M339.7 | 70.2 |
| DuPage | 38,044 | 720 | 83 | L1,893 | L218.2 | 115.2 |
| Edgar | 27,336 | 844 | 83 | M3,088 | M303.7 | 98.3 |
| Edwards | 10,049 | 949 | 21 | H9,452 | L209.1 | 22.1 |
| Effingham | 20,055 | 1,120 | 83 | H5,586 | M413.9 | 74.1 |
| Fayette | 28,083 | 1,374 | 82 | H4,893 | L292.0 | 59.7 |
| Ford | 17,096 | 618 | 67 | M3,616 | M392.0 | 108.4 |
| Franklin | 31,466 | 2,284 | 244 | H7,260 | H775.6 | 106.8 |
| Fulton | 52,501 | 2,022 | 244 | M3,851 | H464.8 | 120.6 |
| Gallatin | 14,628 | 506 | 53 | M3,461 | M362.5 | 104.7 |
| Greene | 22,363 | 758 | 84 | M3,390 | M375.7 | 110.8 |
| Grundy | 24,183 | 1,415 | 101 | H5,852 | H417.7 | 71.4 |
| Hamilton | 18,227 | 475 | 37 | L2,607 | L203.0 | 77.9 |
| Hancock | 30,638 | 1,286 | 93 | H4,198 | M303.6 | 72.3 |
| Hardin | 7,015 | 263 | 53 | M3,749 | H755.5 | 201.5 |
| Henderson | 9,724 | 294 | 22 | M3,023 | L226.2 | 74.8 |
| Henry | 43,224 | 2,211 | 120 | H5,116 | L277.6 | 54.3 |
| Iroquois | 35,543 | 1,164 | 111 | M3,275 | M312.3 | 95.4 |
| Jackson | 36,262 | 1,344 | 140 | M3,706 | M386.1 | 104.2 |
| Jasper | 18,157 | 806 | 43 | 4,441 | 236.9 | 53.3 |
| Jefferson | 29,973 | 1,142 | 70 | M3,810 | L233.6 | 61.3 |
| Jersey | 13,954 | 774 | 28 | 5,548 | 200.7 | 36.2 |
| Jo Daviess | 22,654 | 1,110 | 43 | 4,901 | 189.8 | 38.7 |
| Johnson | 14,331 | 77 | 56 | 537.3 | 390.8 | 727.3 |
| Kane | 103,386 | 4,321 | 335 | 4,179 | 324.3 | 77.5 |
| Kankakee | 43,919 | 1,449 | 183 | M3,300 | H416.7 | 126.3 |
| Kendall | 10,777 | 292 | 27 | 2,711 | 250.7 | 92.5 |
| Knox | 48,405 | 1,987 | 140 | 4,105 | 289.2 | 70.5 |
| Lake | 73,180 | 3,145 | 1,085 | 4,298 | 1,482.0 | 545.0 |
| LaSalle | 92,208 | 6,681 | 400 | 7,246 | 433.9 | 59.9 |
| Lawrence | 28,072 | 137 | 61 | 4,881 | 217.3 | 445.2 |
| Lee | 27,750 | 441 | 64 | 1,589 | 230.6 | 145.1 |
| Livingston | 40,465 | 3,454 | 121 | 8,536 | 299.1 | 35.0 |
| Logan | 31,564 | 1,015 | 116 | M3,216 | M367.5 | 114.2 |
| Macon | 63,163 | 2,634 | 187 | 4,170 | 296.1 | 71.0 |
| Macoupin | 58,116 | 4,954 | 186 | 8,525 | 320.1 | 37.5 |
| Madison | 112,027 | 4,105 | 399 | 3,665 | 356.2 | 97.2 |
| Marion | 39,188 | 1,915 | 133 | 4,888 | 339.4 | 69.5 |
| Marshall | 15,679 | 920 | 37 | 5,868 | 236.3 | 40.2 |
| Mason | 17,377 | 1,546 | 50 | 8,897 | 287.8 | 32.4 |
| Massac | 15,157 | 434 | 91 | 2,865 | 600.7 | 209.7 |
| McDonough | 26,887 | 1,917 | 73 | 7,094 | 271.5 | 38.3 |
| McHenry | 34,930 | 1,569 | 70 | 4,492 | 200.4 | 44.6 |
| McLean | 68,149 | 3,432 | 243 | 5,036 | 356.6 | 70.8 |

INFLUENZA, Illinois, Fiscal Year, July 1, 1918–June 30, 1919—Concluded

| | Population | Reported Cases | Reported Deaths | Per 100,000 of Population Cases | Per 100,000 of Population Deaths | Deaths per 1,000 cases |
|---|---|---|---|---|---|---|
| Menard .......... | 12,796 | 1,303 | 51 | 10,180 | 398.6 | 39.6 |
| Mercer ........... | 19,723 | 639 | 55 | 3,240 | 278.9 | 86.1 |
| Monroe ........... | 13,508 | 416 | 25 | 3,081 | 185.2 | 60.1 |
| Montgomery ...... | 39,254 | 1,893 | 111 | 4,823 | 283.8 | 58.6 |
| Morgan .......... | 34,420 | 2,949 | 135 | 8,568 | 392.2 | 45.9 |
| Moultrie ......... | 14,630 | 305 | 46 | 2,085 | 314.4 | 150.8 |
| Ogle ............. | 27,864 | 1,008 | 40 | 3,618 | 143.5 | 39.7 |
| Peoria ............ | 110,524 | 10,442 | 491 | 9,428 | 444.3 | 47.0 |
| Perry ............ | 24.075 | 1,426 | 107 | 5,924 | 444.5 | 75.0 |
| Piatt ............. | 16,376 | 1,754 | 45 | 10,710 | 274.9 | 25.7 |
| Pike .............. | 28,622 | 1,261 | 66 | 4,406 | 230.6 | 52.3 |
| Pope ............. | 11,215 | 4 | 18 | 35.7 | 160.6 | 4,500.0 |
| Pulaski .......... | 16.616 | 380 | 62 | 2,288 | 373.3 | 163.2 |
| Putnam .......... | 10,041 | 132 | 19 | 1,314 | 189.2 | 144.9 |
| Randolph ........ | 30,101 | 1,921 | 113 | 6,382 | 375.4 | 58.8 |
| Richland ......... | 15,970 | 490 | 29 | 3,068 | 181.6 | 59.2 |
| Rock Island ...... | 83,767 | 4,502 | 391 | 5,375 | 466.8 | 86.9 |
| Saline ............ | 37,715 | 3,113 | 135 | 8,255 | 358.0 | 43.4 |
| Sangamon ........ | 108,155 | 5,517 | 410 | 5,101 | 379.3 | 74.3 |
| Schuyler ......... | 14,852 | 74 | 43 | 498.3 | 289.8 | 581.6 |
| Scott ............ | 10,067 | 353 | 19 | 3,509 | 188.8 | 53.8 |
| Shelby ........... | 31,693 | 1,040 | 75 | 3,282 | 236.6 | 72.1 |
| Stark ............ | 10,098 | 216 | 17 | 2,140 | 168.5 | 78.7 |
| St. Clair ......... | 149,130 | 7,519 | 595 | 5,041 | 399.0 | 79.1 |
| Stephenson ....... | 39,142 | 1,391 | 98 | 3,554 | 250.2 | 70.5 |
| Tazewell ......... | 34,734 | 2,674 | 135 | 7,699 | 388.7 | 50.5 |
| Union ............ | 21,856 | 885 | 120 | 4,050 | 549.2 | 135.6 |
| Vermilion ........ | 88,894 | 3,525 | 403 | 3,966 | 453.4 | 114.3 |
| Wabash .......... | 16,965 | 385 | 56 | 2,270 | 330.2 | 145.4 |
| Warren .......... | 23,442 | 1,808 | 54 | 7,713 | 230.4 | 29.9 |
| Washington ...... | 18,759 | 1,219 | 40 | 6,498 | 213.3 | 32.8 |
| Wayne ........... | 25,697 | 585 | 90 | 2,277 | 350.3 | 153.8 |
| White ............ | 23,052 | 769 | 63 | 3,336 | 273.3 | 81.9 |
| Whiteside ........ | 34,507 | 2,274 | 113 | 6,589 | 327.5 | 49.7 |
| Will ............. | 92,841 | 1,287 | 376 | 1,386 | 405.0 | 292.2 |
| Williamson ....... | 60,353 | 844 | 160 | 1,398 | 265.1 | 189.6 |
| Winnebago ....... | 76,649 | 1,461 | 300 | 1,906 | 391.4 | 205.3 |
| Woodford ........ | 20,506 | 1,735 | 72 | 8,461 | 351.2 | 41.5 |
| Total.......... | | 223,683 | 25,222 | | | |
| Chicago City ..... | 2,621,419 | 43,371 | 8,459 | 1,654 | 323.7 | 195.0 |
| Cook Co., outside Chicago ........ | 283,481 | 15,765 | 819 | 5,566 | 288.9 | 52.0 |

ILLINOIS FISCAL YEAR, JULY 1, 1918 TO JUNE 30, 1919

Comparison of Cities with Remainder of Including Counties

| City<br>County (Outside) | Population | Per 100,000 population<br>Reported cases influenza | Deaths influenza-pneumonia | Deaths—Influenza-pneumonia, per 1,000 cases of influenza |
|---|---|---|---|---|
| Quincy | 36,883 | 4,454 | 586.8 | 131.8 |
| Adams Co. | 27,705 | 3,368 | 360.9 | 107.2 |
| Cairo | 16,296 | 1,602 | 693.4 | 433.0 |
| Alexander Co. | 9,403 | 5,679 | 553.2 | 9.4 |
| Champaign | 15,865 | 8,339 | 598.8 | 71.8 |
| Urbana | 10,624 | 5,045 | 677.7 | 134.3 |
| Champaign Co. | 29,050 | 6,615 | 668.3 | 101.1 |
| Mattoon | 12,996 | 10,111 | 400.1 | 39.6 |
| Coles Co. | 21,846 | 5,905 | 508.1 | 86.0 |
| Chicago | 2,621,419 | 1,654 | 584.4 | 353.2 |
| Cook Co. | 283,481 | 5,563 | 518.0 | 93.0 |
| DeKalb | 10,036 | 4,812 | 458.3 | 95.2 |
| DeKalb Co. | 24,917 | 2,219 | 402.5 | 19.9 |
| Kewanee | 19,184 | 6,778 | 372.9 | 55.0 |
| Henry Co. | 24,040 | 2,770 | 424.3 | 153.2 |
| Galesburg | 25,155 | 5,702 | 481.0 | 67.0 |
| Knox Co. | 23,250 | 2,379 | 322.5 | 135.6 |
| LaSalle | 12,495 | 1,521 | 920.4 | 60.5 |
| Streator | 14,313 | 11,801 | 1,020.0 | 86.4 |
| LaSalle Co. | 55,865 | 4,716 | 426.0 | 100.9 |
| Decatur | 44,261 | 1,701 | 423.6 | 197.8 |
| Macon Co. | 18,902 | 9,147 | 402.1 | 44.0 |
| Alton | 30,036 | 3,702 | 464.2 | 131.3 |
| Madison Co. | 63,515 | 3,608 | 538.9 | 149.3 |
| Bloomington | 27,663 | 3,561 | 571.2 | 160.4 |
| McLean Co. | 40,480 | 5,986 | 383.3 | 64.0 |
| Jacksonville | 15,543 | 10,030 | 855.7 | 85.3 |
| Morgan Co. | 18,877 | 7,199 | 360.2 | 50.0 |
| Peoria | 72,184 | 11,374 | 669.1 | 58.8 |
| Peoria Co. | 38,340 | 6,457 | 546.8 | 84.7 |
| Rock Island | 32,561 | 2,442 | 540.5 | 274.0 |
| Rock Island Co. | 23,230 | 5,349 | 779.2 | 136.4 |
| Springfield | 64,877 | 5,860 | 678.2 | 115.7 |
| Sangamon Co. | 43,278 | 4,009 | 318.9 | 80.5 |
| Belleville | 21,161 | 9,593 | 926.2 | 96.5 |
| East St. Louis | 78,213 | 5,043 | 719.8 | 142.8 |
| St. Clair Co. | 49,756 | 3,105 | 154.8 | 49.8 |
| Freeport | 19,844 | 4,812 | 462.5 | 96.3 |
| Stephenson Co. | 19,298 | 2,259 | 243.6 | 107.8 |
| Pekin | 12,137 | 4,070 | 667.4 | 164.0 |
| Tazewell Co. | 22,597 | 9,647 | 508.9 | 52.8 |
| Danville | 32,969 | 2,563 | 785.6 | 366.5 |
| Vermilion Co. | 55,925 | 4,810 | 448.8 | 93.3 |
| Joliet | 39,353 | 480 | 947.8 | 1,974.0 |
| Will Co. | 53,925 | 2,036 | 421.0 | 206.7 |
| Rockford | 60,213 | 2,031 | 634.4 | 312.3 |
| Winnebago Co. | 16,436 | 1,448 | 7,676.0 | 5,294.0 |

# SANITARY DISTRICTS IN ILLINOIS

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When Illinois was first settled each individual or family made provision to secure its own water supply and to dispose of its own wastes. As villages and cities grew in size the difficulty of securing water and disposing of wastes increased.

By natural development municipalities installed public water supplies and cared for the removal of wastes. With water from a public supply available the most convenient method of disposing of much of the waste was by water carriage through sewers. That method of disposal is now in general use in all of the larger cities. Many of the earlier settlements were on the banks of the larger streams or on the shores of lakes and the natural point of discharge for sewage or liquid wastes was in the streams or lakes. Later, with the development of railroads, many cities sprang up in localities where there were no large water courses. Sewage from such communities was carried to a small stream or, in many instances, to a ditch which was dry for a considerable portion of the year.

Sewage has been discharged into streams until they are polluted, the degree of pollution depending upon the amount of sewage and the flow of water in the stream. In many places pollution has become serious and the water cannot be satisfactorily used for drinking, fish life has disappeared, the stream cannot be used for pleasure purposes, and noxious odors have caused many complaints.

Cities have grown and it has become necessary to dispose of sewage by means other than discharge into a ditch or small stream close to the city. With increase in the number and size of cities the distances between them have decreased and the need of better disposal of sewage has increased. In order to allow better means of disposal laws have been enacted by the State Legislature providing for the creation of sanitary districts and for the disposal of sewage from territorities included in the districts. In accordance with the provisions of these

ıws the Sanitary District of Chicago, the North Shore anitary District, the Decatur Sanitary District, and the loomington and Normal Sanitary District, have been ormed.

SANITARY DISTRICT OF CHICAGO

For many years Chicago discharged sewage into Chiago River and Lake Michigan. The amount of sewage ischarged became very great and as water from the ıke was used for a public water supply other means of isposing of the sewage became necessary. In 1889, nder the provisions of an act to create sanitary districts, nd to remove obstructions in the DesPlaines and Illiois rivers, the Sanitary District of Chicago was organized. The law provides that whenever any area of ontiguous territory within the limits of a single county ontains two or more incorporated cities, towns or villges so situated that the maintenance of a common outlet or the drainage thereof will conduce to the preservation f the public health, area within the limits of the cities ıcorporated towns or villages and within three miles ıereof may be incorporated as a sanitary district.

Any 5,000 legal voters resident within the limits of a roposed sanitary district can petition the county judge ) cause the question of organization to be submitted to ıe voters. The law provides for the creation of a board f trustees of nine members, which board exercises all ıe powers and controls all the affairs of the district. The oard has power to provide for the drainage of the disict by laying out, establishing, constructing and mainıining channels, drains, ditches and outlets, with necesıry adjuncts, for carrying off and disposing of the rainage (including the sewage) of the district. The law rovided for the levy and collection of taxes for corporte purposes the amount of which in any one year should ot exceed one-half of one per centum of the assessed aluation of the taxable property, and for the issue of onds. Indebtedness could not exceed five per centum f the valuation of the taxable property within the disict provided this five percentum did not exceed the ım of $15,000,000.

The law has been modified from time to time by amendments which include acts conferring police power, allowing additional taxation for specific times and purposes changing the limit of bonded indebtedness, providing fo a minimum flow depending upon the population of th district, authorizing enlargement of the district, providing for converting power available into electric energy and amending sections in regard to the election of trustees.

The primary purpose of the work of the Sanitary District of Chicago has been sanitation and sanitary conditions have been greatly improved. It constructed th canal from Robey St., Chicago, to Lockport, and diverted sewage from Lake Michigan to this channel, through which it flows to Des Plaines River and thence to Illinois River. A channel has been cut from the lake at Wilmette southward to a connection in the North Branch of Chicago River and a channel known as the Calumet Sag Channel is being constructed to drain areas in the southern part of the district. Investigations have been made of methods of treating sewage and experimental sewage treatment plants have been operated. Chicago River has been deepened and widened and obstructions have been removed, and valuable water power has been developed.

The title and certain provisions of the act under which the Sanitary District of Chicago was formed practically limit the application of the act to that district.

### NORTH SHORE SANITARY DISTRICT

In April, 1914, the North Shore Sanitary District was created in accordance with "An Act to create sanitary districts, and to provide for sewage disposal." This act, passed and approved in 1911, and amended in 1913, 1915 and 1919, provides for the creation of sanitary districts in territories within one county, including two or more incorporated cities, towns or villages owning and operating either or any of them, a system or systems of waterworks and procuring a supply of water from Lake Michigan.

This district extends along Lake Michigan from the orth to the south line of Lake County. The proceedings or the establishment of the district were practically the ame as those by which the Sanitary District of Chicago as formed. Three hundred instead of five thousand etitioners were necessary to bring the matter up for ection. Bond issues with indebtedness not to exceed amount five per centum of the value of taxable property within the district are provided for and taxes can be vied not to exceed in any year one third on one per entum of the value of taxable property within the district limits.

The board of trustees has power to provide for the isposal of sewage and to preserve the water supplied the inhabitants from contamination and for that purpose may construct and maintain conduits, pipes, chanels, drains and outlets. It must provide suitable and odernly equipped sewage disposal works or plants for e separation and disposal of all solids and deleterious atter from the liquids, and must treat and purify the esidue of such sewage so that when it flows into any lake will not injuriously contaminate the water. The board as power to enter into contract with any city or village or the reduction, treatment and disposal of any garbage r offal, or solid matter removed from sewage at any isposal plant or treatment works.

The district has acquired 30 acres of land for the loation of a purification plant, has investigated methods f sewage treatment, and has raised money which is vailable for construction.

## ENERAL LAW PROVIDING FOR THE FORMATION OF SANITARY DISTRICTS

The laws under which the Sanitary District of Chicago nd the North Shore Sanitary District were formed were mited in their application by provisions of the acts.

In 1917 the Fiftieth General Assembly passed "An ct to create sanitary districts and to provide for sewge disposal". It provides that whenever any area of ontiguous territory contains all or parts of one or more

incorporated cities, towns or villages, and is so situate that the construction and maintenance of a plant c plants for the purification and treatment of sewage an the maintenance of a common outlet for the drainag thereof, will conduce to the preservation of the publi health, the same may be incorporated as a sanitary dis trict under this Act. No territory can be included, how ever, which is not within the limits of a city, incorpor ated town or village, or within three miles outside thereo

Any one hundred legal voters, resident within the lim its of a proposed sanitary district may petition the count judge of the county in which the proposed district, or th major portion thereof is located, to cause the question t be submitted to the legal voters of such proposed dis trict whether such proposed territory shall be organize as a sanitary district under the Act. According to pro visions of the act, upon filing the petition in the office o the county clerk, a board of commissioners is organized consisting of the county judge and two judges of the Cir cuit Court. At a meeting of this board, of which twenty days' notice is given, all persons in the proposed dis trict have an opportunity to be heard in regard to th location and boundary of the district. The board of com missioners determines the limits and boundaries whicl are incorporated in an order spread at length upon th records of the County Court. A majority vote at a election held within sixty days of the time of entering th order, at which each legal voter resident within the pro posed sanitary district has the right to cast a ballot and notice of which is given by the county judge at least twenty days prior thereto, is required for organizatio of a district.

The corporate authority is a board of trustees consisting of three members appointed by the county judge. This board exercises all powers and manages and controls all the affairs and property of the district. It passes all necessary ordinances, rules and regulations for the management and conduct of business of the board of trustees and of the corporation and for carrying into effect the objects for which the sanitary district is formed. It has

ower to provide for the disposal of the sewage of the strict and to preserve the water supplied to the inhabi- nts of such district from contamination. The board ay construct and maintain conduits, pipes, channels, rains, ditches, and outlets for carrying off and dispos- g of the drainage (including the sewage) of the district gether with such adjuncts and additions as may be nec- ssary or proper to cause such channels or outlets to ac- omplish the end for which they are designed. The board ay also treat and purify the sewage so that when the ame flows into any lake or other watercourse, it will not njuriously contaminate the waters. The board may adopt ny other feasible method to accomplish the object for hich the district is created, and may also provide means hereby the district may reach and procure supplies of ater for diluting and flushing purposes. The board of rustees is not authorized to operate a system of water orks for the purpose of furnishing or delivery of water o any such municipality or the inhabitants thereof, or to ow sewage of a district into Lake Michigan.

A district may acquire by purchase, condemnation, or therwise any and all real and personal property, right of ay, and privilege, either within or without its corporate imits that may be required for its corporate purposes. n case any district formed is unable to agree with any ther sanitary district upon the terms under which it is ermitted to use the drains, channels or ditches of such ther sanitary district, the right to so use the same may e acquired by condemnation.

The corporation may borrow money and become in- lebted to an amount not in excess of five per centum of he valuation of the taxable property in the district pro- ided the proposition to issue bonds is carried by vote at lection held in the district according to provisions of he act. All bonds issued mature in not exceeding twenty nnual installments. At the time of, or before incurring ny indebtedness, the board of trustees provides for the ollection of a direct annual tax sufficient to pay the in- terest on the debt as it falls due, and also to pay and dis- charge the principal as it falls due, and at least within

twenty years from the time of contracting the same. The board may levy and collect other taxes for corporate purposes upon property within the territorial limits of the district, the aggregate amount of which for each year shall not exceed one-third of one per centum of the value of the taxable property within the corporate limits, as the same is assessed and equalized for the State and county taxes of the year in which the levy is made, provided however, that a like sum in addition, a total of two-thirds of one per centum, may be levied when such additional tax has been authorized by the legal voters of such district at an election duly held. Any district formed under provisions of this act has the right to permit territory lying outside its limits, whether within any sanitary district or not, to drain into and use any channel or drain made by it, upon payments, terms and conditions mutually agreed upon, and it has full power and authority to contract for the right to use any drain or channel which may be made by any other sanitary district upon terms mutually agreed upon.

This Act provides for the formation of sanitary districts anywhere in the State and with increasing size of municipalities, and consequent increase in amount of sewage produced in such municipalities, many districts will undoubtedly be formed in the near future. In addition to providing a better means of sewage disposal in many cases than could be secured by municipalities acting individually, it provides for obtaining money for carrying on work without regard to the debt of municipalities included in the district.

### DECATUR SANITARY DISTRICT

The Decatur Sanitary District was organized in August 1917. Money has been raised by taxation, and on February 24th an election will be held to decide if the tax rate may be raised to 2-3 of 1 per cent, and if bonds, $860,000 in amount, shall be issued. The board of trustees has employed engineers, prepared plans for intercepting sewers, and let contract for a small amount of construction. If this bond issue is authorized by vote on February 24th,

a contract for intercepting sewer will be let in the near future, and it is expected that money will be available for a purification plant.

BLOOMINGTON AND NORMAL SANITARY DISTRICT

The Bloomington and Normal Sanitary District was organized in November, 1919. An area of about eight square miles, includng the two cities from which the district takes its name, with the exception of about one square mile area which was previously included in a drainage district, is included in the district. Surveys are now being made for an intercepting sewer.

These districts can be of mutual aid to each other and are co-operating with the State Water Survey Division in a study of sewage purification in the testing station of the Division. Many other cities which have need of more adequate sewage disposal can with advantage make use of the privileges granted in these acts.

## Discussion of Paper by H. B. Hemenway

This subject is one which interests us all as property owners and tax payers. There are certain legal aspects which demand consideration.

Streams and lakes are the natural source of water supply for our cities. They are also natural outlet for our sewers. The one demands that the purity of the water be preserved, and the other naturally causes dangerous pollution.

A city which provides water for its citizens for pay does so, not in its governmental capacity, but as a semi-public corporation. As such it is liable for any damage which may result from impurity of the water sold. So, in Keever v. Mankato (113 Minn. 55) the city was held in damages for the occurrence of typhoid fever, resulting from impurity of its supply. There have been many other similar decisions.

There are also numerous decisions to the effect that a city has no more right to maintain a public nuisance than has a private individual. The discharge of sewage into a stream, thereby causing pollution, is a nuisance. If it be a private nuisance, affecting few people, the city or individual causing the damage may be held liable in civil damages, or sometimes it may be enjoined. When, however, the pollution is of water used for a public water supply the act is a public nuisance and it may be enjoined. Not only so, but the city or individual causing the damage may be held in civil damages for all harm done. The upper city may be compelled to pay the expense of the lower city in maintaining its filter plant, and it may be held in addition for sickness and deaths resulting from the impurity of the water.

It has sometimes been claimed that use for over twenty years gave a prescriptive right. That might be so held as regards a private nuisance, but the courts have repeatedly held that no amount of usage could give a prescriptive right to maintain a public nuisance. Where the action has been against private individuals it has sometimes been held that those who had been so discharging private sewage for twenty years might have a prescriptive right, as against other individuals; but the fact that A had so used it for twenty years gave no prescriptive right to B who had only discharged his sewer into the stream for ten years.

In the case of Attorney General vs. Grand Rapids (175 Mich. 503) the plea of prescriptive right was made. The court again affirmed the dictum that no amount of usage could give a prescriptive right to commit a public nuisance; and it added that the fact that Grand Rapids so discharged its sewage when it was a small city give the large city no prescriptive right. Prescriptive right is limited to the kind and amount of usage which was maintained for over twenty years.

In Attorney General v. Birmingham, etc. Drainage District, (1910, L. R. I. Ch. 48) an injunction was granted against the discharge of the drainage district into a stream, but on appeal Sir William Ramsey was ap-

pointed to make a chemical and bacteriological investigation. He found that the sewage was so treated and purified that the water of the stream was actually less impure below the outlet of the sewer than it was above. The injunction was dissolved. Finally, on appeal to the House of Lords (1912, A. C. 788) the dissolution of the injunction was sustained, but with the provision that the purification must be maintained.

Cities must purify their sewage before turning it into streams. It will cost less to maintain proper Imhoff tanks and other purification works than it will to pay damages, and the tendency is to hold cities more rigidly to these requirements.

## DISCUSSION OF PAPER BY JOHN R. BALL

As related to the facts stated I may mention conditions at Evanston. South of Hamilton street the government surveyed land, which was taken up, which land was washed away, and its location is now out in the lake.

Opposite where Memorial Hall now stands in the campus I remember a house which stood some distance from the lake. I remember one day hearing a man say that he had cut ten cords of wood between that house and the lake, and one would not notice that any wood had been taken out. All of the foundation of that house long ago disappeared into the lake. It was my observation that the washing out of the banks occurred during north east storms, and that the gain so made by the lake was kept.

Then citizens began to build breakwaters—small piers extending into the lake. These broke the force of the waves, and caused them to deposit sand. Thus land was made. Where I remember to have seen steamers drawing ten or twelve feet of water at the foot of Davis street now there is solid land, made first by the deposit of sand by the lake, and later increased by filling done by the city. The city did not begin to fill in until after the lake had receded.

# Papers on Psychology and Physiology

# A POSSIBLE INTERPRETATION OF THE SYNCHRONOUS FLASHING OF FIREFLIES

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## I. THEORETICAL AND HISTORICAL

Luminescence in living organisms has rarely failed to excite the curiosity and wonder of mankind. The records of travellers and explorers frequently contain accounts of various forms of the phenomenon and of its presence in many different varieties of animal life. There have also appeared from time to time a large number of scientific descriptions and explanations relating to the biological function, the chemical production, and the characteristic conditions of its occurrence. In 1910 Mangold (18)[1] was able to collect 649 titles on the subject and in the last decade several scores of additional contributions must have appeared. We are not here concerned, however, with the general subject. Some considerations, like the biological function of the phenomenon and the chemical nature of it, may have important relations to the discussion but time forbids a more detailed examination. Suffice it, then, to remark that among insects it is claimed, first by Osten-Sacken (23), then by McDermott (17) and Mast (19), that luminescence is very likely a secondary sex characteristic, especially so in the fireflies (Lampyridae). Recently Harvey (12) has also reported on the chemical changes that take place during the flashing.

But we are chiefly interested in the problem of the concerted behavior of groups of fireflies and with the published statements regarding this peculiar action. It is claimed in many independent reports that there exists at times a certain unusual synchronism of flashing. Often this synchronism is called rhythmical. In the course of discussion synchronism of action has been described in many different forms of animals, notably the swinging movements of web-worms (16, 24), the rising and falling of harvestmen (Phalangidae) (22, 30), the beating of the wings of the pelican (30), the swaying of the bittern in the grass (9), the wriggling of bees at the entrance of

the hive (11), the knocking of the heads of ants against dry leaves (20, 26), the chirping of crickets (Grillidae) (20, 5), the clucking of frogs (2), and the movements of plant lice, of fireflies on the wing, and even of sensitive plants (2).

In examining these reports the psychologist becomes aware of certain features familiar to him in his study of observation and of testimony; and the writer, having acquainted himself with the subject of rhythm, has taken an additionally keen interest in the discussion. A few years ago he made a special investigation into the problem of visual rhythms and discovered in the present question some elements common also to his former experiments.

First of all, then, as to matters of general psychological significance, we may note these:

1. The observations for the most part occur under uncritical conditions. In some respects the circumstances are akin to those accompanying the observation of many mediumistic performances. In a majority of the reports the writer has noticed an emotional attitude and the description of conditions bordering on the romantic. For example we read:

"We sat gazing enraptured on a pyramid of living light, suspended, as it were, by threads of fairy gold. On a high black walnut tree there had gathered myriads of fireflies, which moving through the dark foliage as if to the time of some enchanter's music, presented a scene of exquisite loveliness, which it is impossible to describe. As the fairy mass revolved, now up, now down, then round as to the measured time of a dance, my companion in ecstasy exclaimed, 'Captain, I would work twelve months for nothing to see such a sight as this.' " (28)

"At one moment every leaf and branch appears decorated with diamond-like fire; and soon there is darkness, to be again succeeded by flashes from innumerable lamps which whirl about in rapid agitation. If stars be the

[1] Numbers in parentheses refer to bibliography at the close of the paper. Page references were not deemed necessary because of the brevity of most of the articles cited.

poetry of heaven, earth has nothing more poetic than the tropical firefly." (6)

"On approaching in canoes, a scene of wondrous beauty presented itself. The light was due to miniature lamps of several thousands of fireflies which were holding festival over what appeared to be a breeding ground." (13)

"As the stage rounded one of the numerous curves on the grade there appeared on our left, apparently in motion, a ghostly incandescence which came and went in regularly repeated flashes and intervals of darkness. The appearance was uncanny and was plainly visible to all the passengers in the stage." (21)

The writer has never witnessed synchronic flashing of this sort but he is convinced that its first appearance must throw the observer into an attitude of astonishment at the beauty of the effect. As our experiments later to be described indicate, the same result has been produced even under artificial conditions of the laboratory. And since few of the reported observations have been repeated, statements concerning the phenomenon may be made without being subject to verification under the same conditions.

2. Again, with few exceptions, notably those of Morse (21) and Hudson (13), the synchronism was noticed by but a single observer in any one case. Concerning some of the conflicting points in the several reports there can be therefore no safeguarded confirmation. As some of the statements indicate, at any rate, the phenomenon is in most places of observation particularly rare in occurrence. Allard (1) thinks that "one may consider himself fortunate if he has observed the phenomenon even once in a lifetime, his observation having occurred more than a dozen years ago, and Morse (20) first reported an experience of fifty years ago. Even though there are a good many independent reports of different occasions, an instance simultaneously reported by several individuals is rare in the literature.

3. This scarcity of testimony concerning the identical event is furthermore embarrassed by conflicting reports

on essential points. The debate on some of these points has already been begun in the literature, but no conclusion agreeable to all has been drawn.

(a) There is the widest divergence of opinion regarding the regularity of the synchronism: If some of the fireflies flashed in unison, how many in proportion were 'out of step'? There was of course no check on the apparent regularity of the synchronism. We know, especially from the work of MacDougall and Woodrow that in rhythmical performance variations from strict time can physically occur without a perceptible difference in the maintenance of the rhythm. The quotations which follow indicate positions assumed on this question by the observers.

"There must have been several thousand insects in each tree, yet the synchronism was so perfect that rarely or never did a single firefly flash at the wrong time." (25)

"From time to time, as if moved by a common impulse, great numbers would flash so closely in unison over the entire field that an extensive sheet of tiny light-points would gleam upon the vision for a moment—and then vanish." (1)

"The majority of the fireflies were flashing in unison but there were some which did not time their flashes with the majority." (4)

"The flashes were not perhaps as regular as an army officer would like to see in regimental drills but were so rhythmic that any one would take note of their action." (20)

"I frequently noticed that small trees and shrubs would be more aglow at certain times than at others, but I never happened to observe a time when a small tree or shrub was all alight one instant and dark the next. In my experience there were always some fireflies flashing in the '*dark*' periods. The times of greatest light occurred when the greatest number of varying flashes coincided." (10)

"* * * It was soon evident that while at a given instant one tree may have been more highly illuminated

han the other, there was nothing approaching periodicity in the phenomenon, and no continuation of it was noticed." (16)

"During these visits we noted that the illumination was never due to a truly synchronous lighting of the lamps of those fireflies engaged in the display but was always of the nature of wave motion spreading out from one or more centers * * *. Strictly speaking there was no *measured* regularity in this concerted response and therefore no *true rhythm.* * * *" (13)

In the most recently reported experimental investigation in the subject, the Snyders (27) observed a regularity in the synchronism with a variation of only a tenth of a second in the flash of fireflies flying in a strata of a uniform temperature coefficient.

(b) Variations occur also in the statements concerning the duration of the synchronism. Some say that the effect lasted for a considerable length of time, others that it appeared sporadically. One of the quotations given above (16) referred to the fact that there was no continuation of effect noticeable. In one report we note that the synchronism did not begin at the first appearance of the flashing:

"After a while a most remarkable synchronism in the flashing appeared to take place * * *. This remarkable synchronism in the flashing sometimes continued several times in succession, * * *." (1)

(c) The question of alternate illumination of trees, in addition to the synchronous effect in any one tree, also arises. There seems to be, in other words, a spatial factor in the distribution of the periodical effect.

In respect to the problem of rhythm, we are at once confronted with several important factors. There can be no rhythm, of course, unless there is accentuation of some member in the measure. It is likely therefore that whenever the term is used in these discussions there is meant simply a periodicity or synchronism, *i. e.*, the wider usage of the term common in some connections, as physiological rhythm, geological rhythm, or, as is less likely, there is already a tacit admission that a rhythm

exists, but that it is subjective as regards the observe This explanation has already been suggested by Crai (9) who refers also to the similar theory advanced in th Dolbear-Shull controversy regarding crickets. It wer better to restrict the effect to that of synchronism.

Other explanations have not been lacking. The earlie writers did not hesitate to attribute to the lower animal a "fine sense of rhythm on the part of each individual' (30). Both by implication and by direct statement th opinion is expressed that the control of the performanc is consciously executed. One writer discusses the subjec in connection with crickets (5):

"It is now a question as to whether these crickets pe ceive the rhythm which is so pronounced in the regula sequence of their chirpings. I believe they must, for i is quite evident that they hear and respond to the pecu liar rhythmical chirpings of their kind, which have be come the common language of the species. If they ar able to recognize the notes of their kind, it is reasonabl to believe that the rhythmical character, as well as pitch manner of delivery, and even more subtle tonal differ ences enter into the recognition."

It is almost gratuitous to assign rhythmic perception t the lower organisms. According to Morgan it is no safe to explain animal action on any higher mental leve than is necessary. Swindle (29) seems to think that th sense of rhythm in the human species does not show traces of inheritance. And the question whether savage have a more pronounced sense of rhythm because, Dela croze fashion, they can often maintain complicate rhythms side by side, has not yet received a final answer In the case of fireflies the added difficulty of seeing th rest, except in the few instances of a spreading effec from several foci (13, 22) is presented. The difficulty o explaining the phenomenon on the basis of a selectiv sex function is materially increased by the synchronism itself (16). To the writer it would seem that if the flash ing is related to the sex activity of the males, as th work of Mast (19) seems to indicate, it cannot be o direct causal assistance, but only of secondary import

ance in the sense of a by-product. And it is furthermore apparent from the researches of Harvey (12) that the release may be very regular provided that the physico-chemical conditions are such that the oxidation of luciferin can be resumed at periodically recurring intervals. It is not necessary therefore to take the extreme view that the flashing is due to movements of the eyelids of the observer, as Laurent concluded (15), or that the matter rests largely upon the suggestion of the observer's mind as Craig infers (9), or that, as Gates remarks (10), "complete synchronism in the flashing of a group of fireflies is simply a very rare accident, occurring when the flashes of the individuals chance to come at the same time."

## II. EXPERIMENTAL

The writer believed that, aside from the varying circumstances attendant upon the observations as noted, a reasonable item in the explanation of the phenomenon in its psychological aspects was the well-known tendency of the human mind to integrate its experiences. If the ticks of a metronome are heard at first in a monotonous and unaccented fashion, soon they will be measured off subjectively into groups; if any unevenness should occur in these beats, it would be overlooked and the grouping would continue as before; and if a number of metronomes were set off at respectively different rates, the subject hearing them all at once would bring order out of chaos and begin to superimpose a grouping on the irregularly beating complex.

The assumption made, then, was this: suppose, as some writers stated, there should be several coincidences among a large number of firefly flashings in a given place. This would be so striking that the periods of darkness might seem in comparison more or less complete; and it would then tend to set the mind of the observer in the direction of subsequent grouping of flashes in patterns supplied, for the most part, by himself. In the case of observers whose rhythmicizing tendencies were not so strong—they are never entirely wanting in the normal human mind—the report would take a different turn

from those of others more emphatically inclined in th
direction.

*Apparatus.* It was our task to reproduce on a small
scale and under laboratory conditions the effect d
scribed in the above reports. That the appearance wa
startling and beautiful most of our observers spontan
ously remarked. Twenty small, 15 watt tubular inca
descent lamps were mounted irregularly over a woode
framework on candelabra bases. Covers for these ligh
were then made out of mailing tubes with one end seale
and a hole punched in this end in diameter a little large
than that of the ordinary pin-hole. The inside of th
tubes was lined with white bristol board to increase th
reflection. But great care was taken to stop all ligh
leaks, even thoes only faintly visible in the dark-roon
The entire arrangement subtended a visual angle c
about 25°, the observer sitting about 5 meters away fro
the framework. The framework was eccentrically pivote
on the wall opposite the observer so as to disturb an
tendency to memorize the pattern of arrangement. Whe
the experiment was not under way, a curtain hung ove
the apparatus in order to prevent the possibility of a
inadvertent exposure of the apparatus to the observe
There was provided also a small greenish light mounte
near the center of the framework which served to giv
the observer the approximate center of fixation. A tel
phone cable with a separate strand for each light carrie
the connections to an adjoining dark-room where th
experimenter was stationed and where the control ap
paratus was located. This consisted principally of
small horizontal brass drum driven by a very smoothl
running clockwork and governor. On the drum wer
mounted strips of paper with perforations for the con
tacts made through twenty separately connected point
ers. Whenever one of the pointers passed over a hol
in the paper the electric circuit for its particular lam
was closed and the lamp would flash. A main switc
and a switch for the momentary flashing of the fixatio
lamp completed the apparatus in the experimenter'
room.

*Observers.* Observers were recruited from the staff, from the graduate students in the Department of Psychology, from the students in the intermediate laboratory, and from the members of a few elementary classes. There were more than a dozen all told; and they ranked in training from naive observation to the capacity for careful analysis of mental processes. With one or two exceptions, which were noted in our results, the observers were uninformed concerning the problem of the experiment or the character and disposition of the apparatus.

*Procedure.* The experiments lasted through the greater part of the year 1919-1920 in the course of which time several modifications in the procedure were made. In the early series only five lights were used. They were flashed on in irregular order and no two in unison. Since we were working with a limited number of lamps, at most only twenty, to produce an effect equivalent to that under natural conditions we had to increase the speed of flashing to about one per second; the duration of the flash equal to .5 sec. and the intervals between flashes of the same duration as the flashes. The Snyders give the most reliable value as to flash and interval: 15 flashes per min. and a 6 sec. duration for the interval. We are now continuing the experiment with these longer time values.

In every experimental series the observer was seated in the dark-room, allowed to rest for about five minutes to permit after-images to disappear and to become "dark adapted," and he was then told to describe as accurately and analytically as possible the effect produced. He was told that a warning signal would appear at about the center of the field which he was to observe and at about three second interval before the observation was to begin. Cotton was inserted in his ears so that no possible noise from the apparatus in the adjoining room could form the basis of grouping even though heard through the closed door. At the end of the series before the light was again turned on the curtain was drawn over the framework suspended on the wall.

From a simple series of five lights, each one flashing at its own peculiar rate, the number of lights flashing in

this manner was gradually increased in successive series, until all twenty lights were in operation. In all cases the length of the flash was the same but the intervals between the flashes varied from .5 sec. to 2.5 sec. in .5 sec. increments. The temporal distribution of all the lights was such that only two out of the twenty could flash at the same instant.

In a final series we tried the effect of continuing a rhythmical grouping that was given four times at the beginning of the series, but passing thence into the utmost irregularity of flashing.

*Results.* It was curious to see the emotional effect of all of our series on the observers. Some of it undoubtedly was due to the appearance of these odd and silent flashings on the wall of a dark-room. But more curious still were the spontaneous associations with fireflies. Some of the remarks, as made by different observers, follows:

"Impression of lightning bugs flitting."

"Idea of lightning bugs."

"I had the idea that I was watching fireflies at night or butterflies flitting about."

"Lightning bugs on a warm night."

"Fireflies in summer."

These statements suggested to the writer that the apparatus which served to isolate the natural conditions on a small scale in the laboratory had not taken away the essential significance of the experiment by carrying the abstraction too far. The fireflies were psychologically there.

But more important is the result derived from nearly every series and from every observer showing the strong tendency to organize the experience into patterns or groups. Sometimes it was a spatial pattern which reminded one of the several sets of trees or shrubs which in the narratives were illuminated in turn, for frequently the introspective reports would reveal a visual arrangement which was superimposed mentally on the experience as it came. As one observer put it, "an indistinct impression of a pattern that recurs and yet cannot be de-

scribed,'' was experienced. These patterns fulfilled the conditions, too, of 'complete unison' described in the narratives. As one observer remarked, ''I was impressed by the lightness and then the extreme darkness as the lights were turned on and off'', when as a matter of physical fact, the apparatus did not furnish any interval when there were no lights lit.

In most cases, however, the organization took the form of a temporal arrangement much like our ordinary rhythmical experiences, as some of the selected introspections show:

''I was conscious of more order in the switching on and off of the lights this time.''

''It suggested a rhythmical procedure on the violin.''

''The idea occurred which meant a rhythmical swinging of church bells in a belfry.''

''The idea of playing of piano was called to mind. The brief flashes of light seemed similar to the light touches given the notes when a fast piece is played.''

Altogether while no mention of rhythm had been made, the reference to it was very common. This rhythmical grouping, involving a subjectively produced 'synchronism', was all the more marked when the observer was carried along by the suggestion of the initial groupings which were actually produced in the last series.

*Summary and Conclusion.* Our experiments seem to indicate that under conditions which simulate the natural ones there is a strong tendency to read into the experience, that is presented in a disorganized manner, something of order and regularity. We are continually associating and integrating into groups. This is as true of our simple impressions as it is of our higher and more complex processes of reasoning. A treeful of fireflies flashing each one to his own sweet will is not faithfully observed in the first place nor faithfully reported in the second place. The writer sees nothing to invalidate the empirical results of the Snyders or of Mast, nor does he find himself inclined to doubt the statements made concerning the apparent temporary coincidence of the thousands of flashes that is, for a brief space of time;

but he is inclined to question the reports of prolonged and of absolutely unified flashing when it is implied that the prolongation and the unification lies outside of the mental activities of the observers.

In any event, the results of our own experiments are quite positive; we did get the reports of rhythms from our observers in the majority of cases when there were no physical rhythms presented. The rhythms were both of the visual pattern and of the temporal type with some auditory imagery serving as accompanying ideas. In the first type the pattern was principally extended in space, although repeated in time, while in the second there was mainly a synchronism without visual extension.

The only criticism then can come from the conditions of the experiment in that the necessary abridgment of factors, such as the reduction in numbers of flashes, their change in time, and the attitude of the observer, has produced an artificial result, or at least a result incomparable with the natural effect. We are now proceeding with further modifications in these directions, and we offer the present report temporarily as a suggestion toward a possible solution on the psychological side, so that in the final analysis, if there is to be one, we shall be able to recognize on the physical side the influence of temperature as a regulator of the chemical oxidation in the presence of an enzyme and on the psychological side the influence of the mental functions of the observer in carrying his report to its proper logical conclusion.

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## THE CUMULATIVE EFFECT OF ROTATIONAL INCREMENTS

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The interest of science in the functions of the semicircular canals goes back almost a hundred years to the time when Purkinje, the Austrian physiologist, gave a remarkably complete description of the mental experiences commonly known as dizziness or vertigo.[1] In his account Purkinje observed that certain eye-movements and a general confused orientation accompanied long-continued rotation, and he came to the conclusion that these events, both organic and mental, were the result of the inertia of the soft parts of the body and especially of the

[1] Purkinje, J. Beitrage zur näheren Kenntnis des Schwindels nach autognostischen Daten. Med. Jahrb. d. österr. staates, 1920, 6, 79-125. Erasmus Darwin (Zoonomia, the laws of organic life, 1795, (3rd ed. 1801), 327-356) had already described in a sane manner the popular facts concerning dizziness but Purkinje seems to have done the first experimental work.

brain. Some years later, Flourens noted that the same kind of behavior resulted from excitation of the cerebellum and of the semicircular canals.[2] In spite of theorists who have variously conjectured that the canals are the end-organs for the appreciation of time and space, or for noise, or for apprehending the direction of sound, evidence has gradually accumulated that the inner ear does contain an end-organ which is non-acoustical in function and which seems to be closely related to the maintenance of organic equilibrium. In the early seventies Mach, a physicist, Breuer, a physiologist, and Crum Brown, a chemist, came independently to the conclusion that the end-ogans in the membranous labyrinth were set into function by the inertia of the liquid enclosing them and enclosed by them. These men supposed that a flow was induced within the canals by forward and backward or rotational movements of the head which excited the end-organs of the vestibular nerve.

During the latter part of the nineteenth century nearly 300 experimental investigations were made on all kinds of animals and upon normal and pathological human subjects.[3] Rotational, thermal, chemical, mechanical, surgical and galvanic means were used to excite the canals, and a brilliant technique led to sound scientific discussion. Most of these studies have confirmed the opinion that the canals are closely related to the maintenance of position. It has not been established, however, that the canals contain the sole end-organs of equilibration, the evidence indicating rather that the maintenance of position is the product of a large number of factors.

Now chief among the organic and mental effects resulting from stimulation of the canals, or of one branch of the VIIIth nerve, or of the cerebellum, are certain ocular effects known as nystagmus. Investigators were not slow to suggest that these ocular movements, consisting of a slow movement of the eyes to the right or the

[2] The best account of Flourens' work is found in his "Recherches expérimentales sur les propriétés et les functions du systéme nerveux," Bailliere, Paris, 1842, pp. 438-501. His experimental work, however, began in 1825.

[3] See Griffith, C. R., "A historical survey of the mechanisms of equilibration," to be published in the Psychological Review, Monog. Series, 1920

left and of a sudden jerk back to the original position, bore a definite relation to the direction of the theoretical flow of liquid in the canals.

About 1906 Robert Bárány of Vienna recognized the possible clinical significance of this close relation between the semicircular canals and the eyes and he began, therefore, a series of investigations in the clinical laboratory based upon the work that had already been done. The outcome was a series of tests for the determination of vestibular "normality". The regularity with which the ocular effects usually appear, together with a neurological doctrine based upon investigations of Cajal and Golgi and worked out more in detail for clinical purposes by Hőyges and Ruttin, suggested the assumption that nystagmus was a simple and invariable reflex response to the excitation of the canals and that its appearance could be used as an index of the normal or of the pathological condition of the nerve tracts leading from the canals through the cerebellum to the ocular muscles. Some of these tests, which have come to be known as the Bárány tests, rest essentially upon the supposition that nystagmus is always a reliable index of the functional integrity of the neural pathways concerned.

It thus came about that during the war a small group of American otologists appropriated the results obtained by Bárány and made out of them a series of tests for use in the Air Service of the Army. The nystagmus test was confessedly based upon the assumption that the ocular movements following rotation were simple reflexes comparable in every respect to other well-known reflexes. But while investigating the matter at the Mineola Laboratory, the psychological department found reason to question the simplicity of these ocular responses and after a series of investigations Bentley and others came to the conclusion that these effects were not a reliable index of function of the semicircular canals, in as much as they were discovered to be profoundly influenced by practice.[4] For instance, it was determined that nystagmus might be made to disappear altogether under

[4] See Manual, Medical Research Laboratory, 1918, pp. 186-193.

practice. These results were entirely in keeping with the observation that whirling dancers and acrobats frequently have a shortened after-nystagmus period and that aviators of long experience likewise fail to show a "normal" nystagmus.[5] Further work on the problem was undertaken at the Psychological Laboratory of the University of Illinois and the results of almost two years of work have demonstrated that the ocular effects and all the organic and mental effects of stimulation of the canals tend to decrease in intensity and in duration and in some cases to disappear.[6] It appears, then, as though the ocular effects are not inevitable reflexes and it is not possible, therefore, to use them as they have heretofore been used in the clinical laboratory as an unequivocal index of functional integrity.

In supporting their contentions for the Bárány tests, the otologists appealed to fatigue and to the fact that any temporary decrease was due to "gaze-fixing." In the series of experiments reported in *The Laryngoscope* as well as in our other experiments above mentioned, we have shown that the appeal to "gaze-fixing" is not satisfactory. For example, a group of white rats, which have no organic provision for adequate fixation, were rotated under conditions approximating those for human subjects and in every case the nystagmus and the other organic effects as well were found to disappear under practice within from ten to eighteen rotational periods of ten series each.

In the case of fatigue, the clinicians have not been able to cite any convincing evidence. On the other hand, we have found the decrease which appears under practice to carry over for long periods of time, thus proving that the decrease is not due to temporary exhaustion. In other words all of our experiments have gone to show that nystagmus is not a simple invariable effect of vestib-

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[5] See Parsons, R. P., and Seger, L. H., Bárány chair tests and flying ability. *J. Amer. Med. Ass.*, 1918, 70, 1064-1065.

[6] See Griffith, C. R., The decrease in after-nystagmus during repeated rotation. *The Laryngoscope*, 1920, 30, 129-137; The organic effects of repeated bodily rotation, *J. of Exper. Psychol.*, 1920, 3, 15-46; An experimental study of dizziness, *ibid.*, 1920, 3, 89-125.

ular stimulation but that, on the contrary, it is highly variable in its appearance. Moreover, it is but one of a large number of effects which contribute to that complex experience known as dizziness.

As further evidence on the nature of nystagmus resulting from rotation we have instituted a series of experiments in which subjects were started with a number of revolutions so small that none of the usual effects was obtained. We then gradually increased from day to day the number of turnings. It will be observed that this procedure is just the reverse of what has usually been done, *viz.*, starting subjects with as many as ten revolutions in order to get rotational effects of optimal intensity, and so to note the decrease in the intensity and duration of these effects as practice continues. In our new series, it was found possible finally to rotate a subject as many as ten revolutions without, at any time, having produced nystagmus or any of the other effects usually found. That is to say, in our former experiments, the number of turnings was kept constant from day to day, the changes occurring in the duration and in the intensity of the rotational effects. In our new series, the rotational effects continually failed to appear and were thus in a sense, as we shall see, constant, while the number of revolutions was constantly increasing.

In order to carry out these experiments six subjects, underclassmen in the University of Illinois, were given the usual clinical nystagmus and past-pointing tests for "normality". The Bárány tests for "vestibular normality" mentioned above, have given the following significance to the term "normal." It means that after ten revolutions in twenty seconds, either to the right or to the left, the after-nystagmus should last for about twenty-five seconds. Furthermore, if, after ten revolutions, the subject is asked to raise his arm quickly above his head and then to lower it to a point he supposes to be directly in front of him, he will usually 'past-point' either to the right or to the left, according to the direction of rotation. All of our subjects past-pointed "normally", that is, approximately three times. The after-nystagmus times, the

number of eye-movements made, and the length of time during which the subject perceives the visual field to be in apparent movement were registered by means of a kymograph and electric signal markers. The results appear in Table I. They interest us, however, not as an index of "normality" (our whole discussion shows that they cannot be so used without certain reservations) but as indicating the extent of the organic and mental effects to be overcome by practice in our experimental series.

TABLE I

| | Rotation to left | | | Rotation to right | | |
|---|---|---|---|---|---|---|
| Subject | Time | Number | App. Mvt. | Time | Number | App. Mvt. |
| A | 32.0 | 50.0 | 31.0 | 29.0 | 52.0 | 29.0 |
| B | 21.0 | 27.0 | 22.0 | 20.0 | 24.0 | 20.0 |
| C | 23.0 | 56.0 | 23.0 | 23.0 | 47.0 | 23.0 |
| D | 22.0 | 35.0 | 22.0 | 21.0 | 29.0 | 21.0 |
| E | 28.0 | 30.0 | 28.0 | 26.0 | 36.0 | 26.0 |
| F | 24.0 | 35.0 | 24.0 | 24.0 | 40.0 | 24.0 |
| Average | 25.0 | 38.8 | 25.0 | 23.8 | 38.0 | 23.8 |

Each of our subjects was then rotated from day to day in an improved form of the Bárány rotation chair. On the first and second day's trials each subject was given but one revolution for each trial during a rotation period consisting of ten trials. On the third day the subjects were given two revolutions at each trial. From this point on, the number of revolutions in a trial was increased from time to time as the several subjects permitted. For example, if it was found after two days rotation periods of ten trials each and two revolutions to a trial that a subject could then be revolved three times without the appearance of nystagmus, he was given at the next regular session ten trials of three revolutions each. In this manner, the number of continuous turns was gradually increased until the investigation was discontinued. Extreme care was taken at all times to avoid passing to a greater number of turnings when to do so would arouse a perceptible quiver of the eye. On the other hand, because of uncontrollable changes in the organic conditions of the subjects, and because of the fact that the progress in the development of inhibitions against the appearance of nystagmus was so closely pursued, it was not possible

to avoid the appearance of nystagmus when it came as a small relapse. For example, a subject may have been accustomed to six turnings and have been ready to pass to seven save that organic distress (which, as we have found in other experiments, tends to increase the intensity and duration of the nystagmus) made it impossible for the subject to stand more than four or five turnings without nystagmus. In such cases, and they were too few to seriously affect the experiment, the subject was continued at the old number of turnings until he was physiologically stable again.

We shall now discuss the results. By inspecting Table II, it will be seen that, at the time the investigation was discontinued, subjects C and F could be rotated ten times

TABLE II

Giving the number of rotation-periods of ten trials (each trial consisting of the designated number of revolutions) necessary to enable the several subjects to pass to the next higher number of revolutions per trial without the appearance of nystagmus. That is to say, Subj. A, for example, was given 1 rotation-period of ten trials, each trial consisting of one revolution. He then spent 4 rotation-periods where each of the trials consisted of two revolutions and so on.

| No. of revolutions per trial | Subjects | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| 2 | 4 | 2 | 3 | 2 | 4 | 3 |
| 3 | 2 | 3 | 2 | 2 | 2 | 3 |
| 4 | 2 | 3 | 1 | 2 | 3 | 2 |
| 5 | 1 | 4 | 3 | 6 | 3 | 2 |
| 6 | 1 | 7 | 1 | 6 | 2 | 2 |
| 7 | 4 | 2 | 2 | 5 | .. | 4 |
| 8 | 3 | .. | 6 | .. | .. | 4 |
| 9 | 6 | .. | 6 | .. | .. | 5 |
| 10 | .. | .. | 3 | .. | .. | 4 |

in twenty seconds without a perceptible quiver of the eye. Subject *A* was discontinued at nine turns per trial, subjects *B* and *D* at seven turns and subject *E* at six. There is no reason to suppose, however, that these subjects would not ultimately have given the same results as subjects *C* and *F*.

Table III shows, in terms of the number of single revolutions, the general course of the increasing inhibition against nystagmus. The fact is revealed that the effect of practice is greater at the beginning of a series than at

TABLE III

The figures indicate the actual number of revolutions given to each subject as the number of revolutions per trial increased up to ten. In the column of averages, the small number for 10 revolutions per trial is due to the fact that subjects *C* and *F* were not rotated long enough to enable them to pass to *eleven* revolutions per trial.

| No. of revolutions per trial | Subjects | | | | | | | Reciprocals |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | Av. | base=1002.0 |
| 1 | 20 | 40 | 20 | 20 | 20 | 20 | 23.6 | 41.7 |
| 2 | 160 | 80 | 120 | 80 | 160 | 120 | 120.0 | 8.3 |
| 3 | 120 | 180 | 120 | 120 | 120 | 180 | 140.0 | 7.1 |
| 4 | 160 | 240 | 80 | 160 | 240 | 160 | 173.3 | 5.8 |
| 5 | 100 | 400 | 300 | 200 | 300 | 200 | 250.0 | 4.0 |
| 6 | 120 | 420 | 120 | 720 | 240 | 240 | 305.0 | 3.3 |
| 7 | 560 | 280 | 280 | 700 | ... | 560 | 476.0 | 2.1 |
| 8 | 480 | ... | 960 | ... | ... | 640 | 693.3 | 1.4 |
| 9 | 1,080 | ... | 1,080 | ... | ... | 900 | 1,002.0 | 0.0 |
| 10 | .... | ... | 600 | ... | ... | 800 | 700.0 | 1.4 |

the end. In other words, it takes a greater amount of practice to be able to stand nine turns after having stood eight than it does to stand three turns after having become accustomed to two. Or, again, it took 640 turns for subject *C* to become accustomed to five turns a trial but it took 3,040 turns to stand the increase up to ten turns per trial. In a similar way it took 680 rotations for subject *F* to become accustomed to 5 turns a trial while 3,140 were required to go to ten turns per trial. These facts illustrate a common characteristic of the change that takes place in the organic and mental effects of rotation during practice. That is, a curve showing the increasing ability of a subject to stand rotation without presenting any organic or mental effects possesses some of the characteristic of the typical learning curve.

That this is true can be seen by recalling the general form of the learning curve and by comparing it with the curve of Chart I. Chart I is based upon the results obtained from the experiments we are now discussing. (See Table III) If becoming accustomed to rotation can be spoken of as a "performance" then it will be seen that the degree of performance is much greater during the early part of a series than later.[7]

[7] Compare the curve in chart I with those obtained from subjects who began with ten revolutions per trial or approximately 25 revolutions of after-nystagmus. See *J. of Exper. Psychol.*, 1920, 3, p. 30.

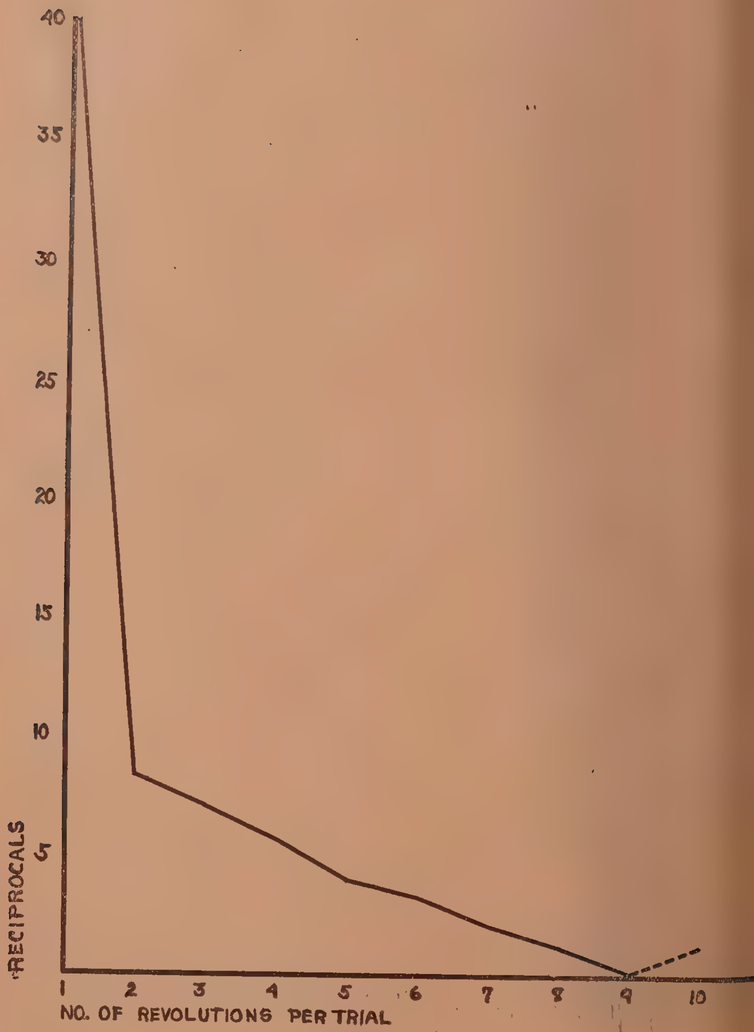


CHART I

The curve represents the temporal curve of the increasing inhibition o nystagmus as revolutions increase in number per trial. Distances alon the ordinate are reciprocals of the total number of revolutions.

The after-nystagmus was not the only effect of rotation that was altered by practice. None of the subjects experienced vertigo at any time. On a few occasions a very slight dizziness was reported; but in most of the cases this was demonstrated to be coincident with the organic disturbances from other causes. None of our subjects past-pointed at the end of the investigation. That the muscular effects of rotation usually leading to past-pointing had dropped out was demonstrated in the following manner. A writing surface was placed in such a position that a subject holding a pencil lightly in his fingers could leave a record of the involuntary movements of his arm. Automatographic records of this kind taken before practice show a marked deviation either to the right or to the left depending upon the direction of rotation. In this case, however, there was no larger deviation than is usually owing to inertia.[8]

That this increasing ability to be rotated without the appearance of nystagmus is not a matter of fatigue is suggested, first of all, by the fact that 24 hours elapsed between successive rotation periods. In the second place, subject *E* was rotated at intervals of from two to three days with the same results as the other subjects. Finally, all of the subjects were rotated again from four to six weeks after the regular series had ended. From Table IV, which summarizes these trials, it appears that, in general, the loss of the effect of practice is negligible, subjects *C* and *F* showing no nystagmus after ten revolutions and the other subjects showing but a fraction of the original values. Subject *A* presents an apparant exception to this generalization. By refering to Table I, however, it will be seen that *A's* original values were unusually high. Furthermore, enough evidence has been collected to show that the appearance of after-nystagmus is largely dependent upon the conditions under which rotation is done. These conditions are both physical and mental and they are not always obvious to the experi-

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[8] For a fuller description of this method and for more complete results in other experiments see Griffith, C. R. *J. of Exper. Psychol.*, 1920, 3, 36-37.

menter.[9] Finally the rapid decrease in all the values for subject *A* during three or four minutes rotation indicates that lost practice effects are soon recovered. In the case of subjects *B* and *D*, it will be seen from Table II that neither of them had gone beyond seven revolutions per trial. Over four weeks later, ten revolutions per trial produced but a third of the original values. These facts clearly point to the conclusion that the modification of the time of after-nystagmus, the number of the ocular movements and the time of apparent movement in the visual field, is more or less permanent. More specifically, the facts prove conclusively that the modifications are not due to fatigue.

TABLE IV

Giving the time of after-nystagmus in seconds, the number of ocular movements, and the time of the apparent movement of objects in the visual field after rotation-trials of ten revolutions (except for subject E). Compare this table with the results shown in Table I.

| | | | Rotation to Right | | | Rotation to Left | | |
|---|---|---|---|---|---|---|---|---|
| Subj. | Interval days | Trial No. | Time | No. of Mvts. | App. Mvt. | Time | No. of Mvts. | App. Mvt. |
| A | 45 | 1 | 18.0 | 20.0 | 19.0 | 16.0 | 18.0 | 17.0 |
| | | 2 | 14.0 | 12.0 | 14.0 | 13.0 | 16.0 | 15.0 |
| | | 3 | 10.0 | 8.0 | 10.0 | 11.0 | 10.0 | 12.0 |
| | | 4 | 7.0 | 5.0 | 6.0 | 7.0 | 6.0 | 7.0 |
| | | 5 | 3.0 | 3.0 | 4.0 | 4.0 | 4.0 | 3.0 |
| B | 32 | 1 | 7.0 | 9.0 | 8.0 | 6.5 | 10.0 | 7.5 |
| C | 32 | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| D | 32 | 1 | 11.0 | 14.0 | 10.0 | 12.0 | 18.0 | 13.0 |
| | | 2 | 3.0 | 4.0 | 3.0 | 4.0 | 4.0 | 3.0 |
| E | 40 | 1 (5 rev.) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| F | 40 | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

In general, then, our experiments have demonstrated that repeated excitation of the semicircular canals which is not of sufficient intensity to produce any observable ocluar effects leads within a comparatively short time to the ability to stand as many as ten turns within twenty seconds without the appearance of after-nystagmus, or of any of the other organic and mental products of rotation. Now if a single excitation of the canals, such as we have used, is called a "subliminal stimulus," so far as regards the production of ocular effects, then these ocular effects

[9] See Griffith, C. R. *op., cit.*, pp. 46, 124.

›ehave in a manner entirely different from that of the vell-known reflexes.

Sherrington[10] has pointed out that, in the typical re-lex, there is no such summation of inhibitory effects as ve have here demonstrated. As a matter of fact, he has lemonstrated that when the interval between successive stimulations is small (1,400 sigma or less) one subliminal stimulus may actually show a facilitating effect on a stim-ulus applied a moment later. At any event, the thresh-hold value just above which the scratch-reflex can be elicited remains constant save when toxic fatigue pro-ducts or drugs are present. In the case of nystagmus, however, there is a constantly rising threshhold value even though it has been demonstrated that fatigue pro-ducts are not present. If in chart II the unbroken hori-

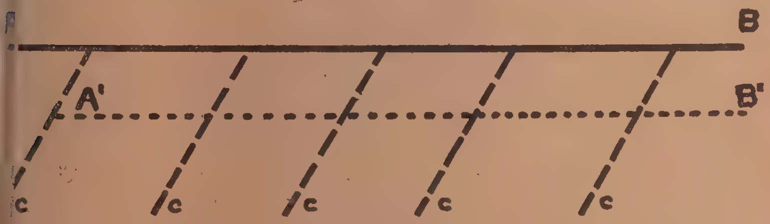


CHART II

The line AB represents the stimulus limen just above which incre-.ents of electrical stimulation will just excite the 'scratch-reflex.' If the ıcrements of stimulus, c,c,c, etc., are given with small intervals, the ıreshhold value drops from AB to A'B'. It is not known to rise above .B save under fatigue or when certain drugs are administered. Neither oes the threshhold value rise above AB if the intervals between the in-rements of stimulus are long.

zontal line represents the threshhold value just above which so many units of electric shock will give rise to the scratch reflex, then the course of repeated stimula-tions of this reflex may be pictured by the dotted and the broken lines respectively. In a similar way, (Chart III) the course of repeated excitations of the end-organs in the canals can be illustrated. It will be seen that in

[10] Sherrington, C. S., The integrative action of the nervous system, 1906, p 37.

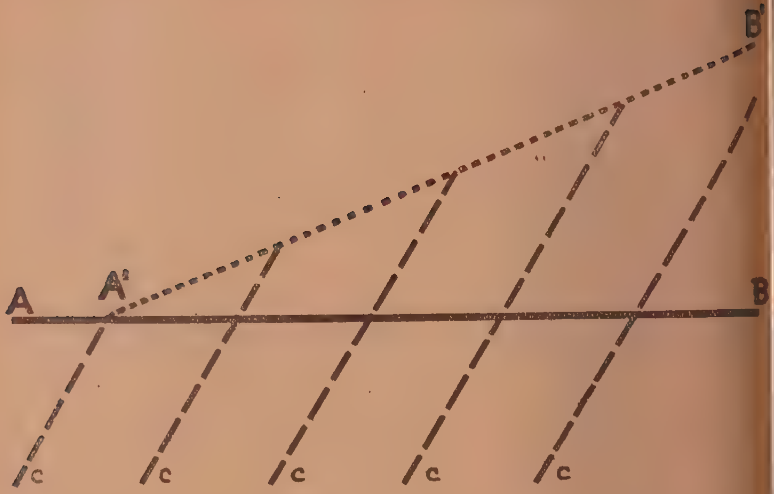


CHART III

The line AB represents the stimulus limen just above which increments of rotational stimulation will just excite ocular movements. If the increments of stimulus, c,c,c, etc., are given at intervals, the threshhold value rises as at A'B'.

order to represent faithfully the course of nystagmus the unbroken threshhold line will have to take the direction of the dotted line. In other words, the threshhold value is constantly rising.

It is apparent, therefore, that nystagmus is profoundly influenced by practice even though the excitation of the end-organs in the canals is constantly "subliminal" so far as regards the production of any observable eye-movement. Moreover, the continued absence during our experiments of all the other effects of rotation indicates that after-nystagmus is but a single constituent of a large group of rotational residues. That is to say, the organic and the mental effects of rotation usually appear and disappear together. These facts, together with the comparison of respective threshhold values under repetition point directly to the conclusion that the ocular movements following rotation cannot be considered as the simple and invariable reflex effects of ampullar excitation.

# EVIDENCE THAT CATALASE IS THE ENZYME IN ANIMALS AND PLANTS, PRINCIPALLY RESPONSIBLE FOR OXIDATION.

W. E. Burge, University of Illinois

We have found that whatever increases oxidation in the animal produces an increase in catalase, an enzyme possessing the property of liberating oxygen from hydrogen peroxide, by stimulating the alimentary glands, particularly the liver, to an increased output of this enzyme, and whatever decreases oxidation produces a decrease in catalase by diminishing its output from the liver and by direct destruction.

The food materials were found to stimulate the liver to an increased output in catalase parallel with the increase they produce in oxidation, the proteins being more effective in this respect than the fats or carbohydrates, in keeping with the fact that protein is more effective in increasing oxidation. The ingestion of saccharin was found to increase catalase and in this way may serve as a food material.

In exophthalmic goiter, a disease in which there is a hypersecretion of the thyroids, it is known that there is a great increase in oxidation in the body. We found that when desiccated thyroid is fed to an animal, it stimulates the liver to an increased output of catalase, which suggests that the increased oxidation in exophthalmic goiter may be due to the increase in catalase brought about by the hypersecretion of the thyroids. It was also found that the catalase content of the tissues was greatly decreased in diabetes, a disease in which oxidation is defective. The decrease in this enzyme may be the cause of the defective oxidation.

The narcotics were found to decrease catalase parallel with the decrease they produce in oxidation by diminishing the output of this enzyme from the liver and by direct destruction. A strong narcotic, such as chloroform, was more effective in this respect than a weaker narcotic, such as ether. A rapidly acting narcotic, such as nitrous oxide, decreased catalase very quickly, while

a slowly acting narcotic, such as magnesium sulphate or morphia, decreased catalase very slowly.

In the plant kingdom, it is known that whatever increases oxidation also produces an increase in catalase, and whatever decreases oxidation in the plant decreases catalase. This parallel relationship suggests that catalase may be the enzyme in plants also principally responsible for oxidation.

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## CAUSE OF THE INCREASE IN THE RESPIRATORY METABOLISM IN THE FERTILIZED OVUM

W. E. Burge, University of Illinois

It is known that by whatever method development of the egg is initiated, whether naturally or artificially, oxidation or respiratory metabolism is always increased.

The respiratory metabolism of the unfertilized egg is low while that of the fertilized egg is high. The unfertilized egg is also poor in catalase, an enzyme possessing the property of liberating oxygen from hydrogen peroxide, whereas the fertilized egg is relatively rich in this enzyme.

We have found that whatever increases oxidation in the animal produces an increase in catalase by stimulating the alimentary glands, particularly the liver, to an increased output of this enzyme, and whatever decreases oxidation produces a decrease in catalase by diminishing its output from the liver and by direct destruction.

These observations suggest that the low respiratory metabolism of the ovum before fertilization may be attributed to the low catalase content of the egg, while the increase in the respiratory metabolism after fertilization with resulting development may be due to an increase in catalase brought about by the stimulation of the egg by the spermatazoon to an increased production of catalase.

# Papers on Botany

Rome apples badly affected with Sooty Blotch

# SOOTY BLOTCH OF POMACEOUS FRUITS[1]

Arthur Samuel Colby, University of Illinois

## I. INTRODUCTION

Sooty blotch, and fly speck, which often accompanies it, which are sufficiently illustrated by Figs. 1 and 2 to make clear the meaning of these names, have been known in a general way in this country for almost nine decades, or since 1832, as the cause of a peculiar spotting or "clouding" of certain pomaceous fruits, especially apple and pear. The names adequately describe the appearance of these fungi, which are commonly found on the fruit. Occasionally other parts of the plant are affected. One or both fungi may be present on the same portion of the host, while if both are found they may be near each other or widely separated. The fungi may appear during the latter part of the growing season except where rainfall is scarce at that time. Such blemishes, while not the cause of decay, usually do cut down very materially the salability of otherwise good fruit.

Notwithstanding the conspicuous character of these fungi and their general distribution, which has resulted in numerous references to their occurrence and suggestions for their control, there has been comparatively little study to determine their morphology, and relation to other fungi. Some authors have held that sooty blotch is distinct from fly speck, others, that the two are merely different forms or aspects of the same fungus. Such opinions have resulted in much confusion, and a wealth of misinformation, handed down from one publication to another. In an attempt to clear up to some extent, such a chaotic condition, a morphological study of sooty blotch on pomaceous fruits was made by the writer. Brief mention is made of sooty blotch as it has been noted on the woody parts of other plants, in some cases with incidental studies of the same, if needed to throw light on common problems of morphology.

[1] The results presented in this article formed part of a thesis submitted by the author to the Graduate School of the University of Illinois in partial fulfilment of the requirements for the degree of doctor of philosophy in botany, May, 1919.

Sooty blotch is strictly superficial. It does not penetrate even the cuticle of the host, and causes no malformation or cellular injury. It cannot, therefore, in the strict sense of the word, be termed a disease and will not be so discussed at this time.

## II. THE FUNGUS

*Names.* The sooty blotch and fly speck have been known for many years under a variety of names. Some authors have used but one common name to include both forms, while others have used two. The common names employed are the following: Fruit spot, ink spot, fly speck, sooty fungus, sooty mold, sooty spot, sooty blotch, cloud, while technically the fungi have been placed in the genera Monilia, Dothidea, Labrella, Xyloma, Sphaeria, Leptothyrium, and Phyllachora.

Practically all the common names listed are quite descriptive and on that account are suitable for common usage. The name, sooty blotch; however, seems definite, and because of its general use, is here adopted as the common name of the fungus.

Much confusion has arisen through the lack of uniformity in names, common as well as scientific, by which the fungus is known. This has resulted in uncertainity on the part of anyone working in this field, as to exactly which fungus is meant by any one common or scientific name. It has therefore been thought wise to include in the bibliography all available references of importance, bearing on either of these fungi.

*History.* The vague and incomplete technical descriptions which have been given of these two fungi make it difficult for the student to be certain which fungus is meant. In early studies of the fungi, stress was quite naturally laid on the taxonomic side. Since 1894, however, the investigations have taken a practical turn, with only a few isolated examples of taxonomic or morphological studies.

What is now known as sooty blotch is first noted and briefly described in this country by Schweinitz (1832),

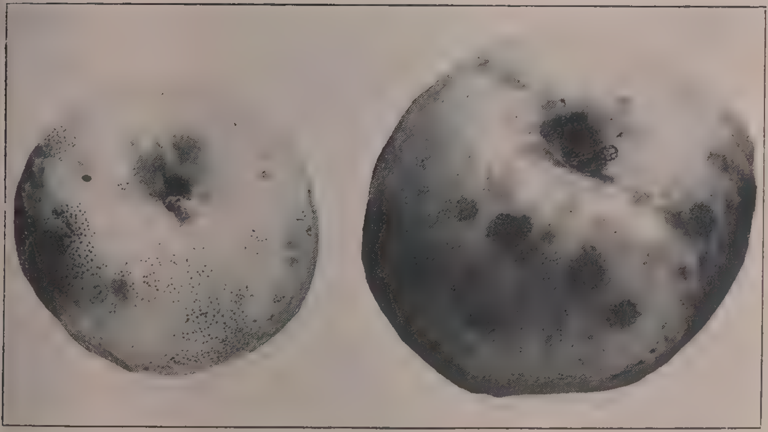


Fig. 1. Sooty blotch predominant on apple shown at right; fly speck on apple shown at left, x ¾

as present on the epicarp of mature apples of the Newtown Pippin variety in Pennsylvania. Two years later, Montagne and Fries (1834) report a fungus on apples that they have received from Dr. Hussenot in Paris, which was either sooty blotch or fly speck. Sprague (1856) gives an interesting description of sooty blotch on apples and states that "the disease" is of common occurrence in New England. Von Thuemen (1879) reports finding what is probably sooty blotch in Italy.

From 1879 till 1894 nothing worthy of note was published, except the taxonomic studies of Saccardo (1883) and (1884). From 1894 on, plant pathologists at the various experiment stations in Canada and this country begin to report the occurrence of sooty blotch and fly speck, and offer suggestions for preventing them. Lamson (1894) of New Hampshire was the first to spray for sooty blotch, and was successful in controlling it. Powell, (1896) using the term "fly speck" to include both forms, discusses its occurrence in Delaware. About this time also, Taft and Davis (1895). and Beal (1897), report sooty blotch and fly speck as being troublesome in Michigan. Also in 1897, Selby (1897) discusses "sooty fungus" and "fly speck fungus" in Ohio. The next year, Sturgis (1898) in Connecticut, gives a somewhat detailed account of the appearance, causal nature, and control of sooty blotch. Beach *et al.* (1899) offer measures for the control of these two fungi, in New York. In 1900, Selby again (1900) describes sooty blotch and fly speck, and recommends control measures in Ohio. Orten (1902-07), in his yearly "Summary of Plant Diseases in the United States," incorporated in the Department of Agriculture Year Books, from 1902 to 1907, when the service in that form was discontinued, reports as to the occurrence of sooty blotch and fly speck, the names used interchangeably. He finds the fungi to be generally prevalent over many of the northeastern and middle western states, with isolated exceptions farther west and south. The next year, Faust (1903) lists "sooty mold" as the cause of a minor but very common trouble in Missouri. Lamson,

the same year (1903), reports satisfactory results in control of sooty blotch while spraying for apple scab.

The first notice the writer has seen of the troubles in Canada, is that by Macoun (1903), who discusses the "sooty fungus or fly speck fungus" with reference to its occurrence in Canada and methods of treatment. Sheldon (1905) finds the trouble prevalent in West Virginia. Wilcox (1905) states that sooty blotch is common in Alabama, and discusses the characteristics of the fungus as it appears in that state, with recommendations for its control. Clinton (1906) believes that sooty blotch is "one of the most serious fungous troubles of the apple in Connecticut". The presence of fly speck in Maryland is noted by Norton and Symons (1907), and recommendations for spraying are given. The fact that the fungus, which is called sooty blotch and fly speck, is less common in Maine than farther south, is emphasized by Morse and Lewis (1910).

The first recorded appearance of sooty blotch in England is by Salmon (1910), and anxiety is expressed that it may become serious, like other troublesome fungi imported from America. The same year, Stevens (1910) gives fly speck a minor place among North Carolina fungi, and claims its control by proper spraying. Howitt and Hayhurst (1911) find "fly speck fungus" on woody portions of various orchard plants in Arkansas, though they refer to no host plants by name. Howitt (1911) briefly discusses sooty blotch in Canada, with suggestions for control. Ballou (1912) gives results of spraying experiments in sooty blotch control, in Ohio. Beach (1912) implies the common occurrence of the two fungi in Iowa, by including recommendations for their control in a spray schedule, while others; Brooks (1912), Clinton (1912), and Quaintance and Scott (1912) in the same year publish spray schedules, the use of which is intended to hold the troubles in check.

In 1916, Salmon and Wormald (1916) find sooty blotch on the pear, for the first time, in England. From 1916 to the present time, still greater stress has been laid on spraying experiments in discovering the best methods of

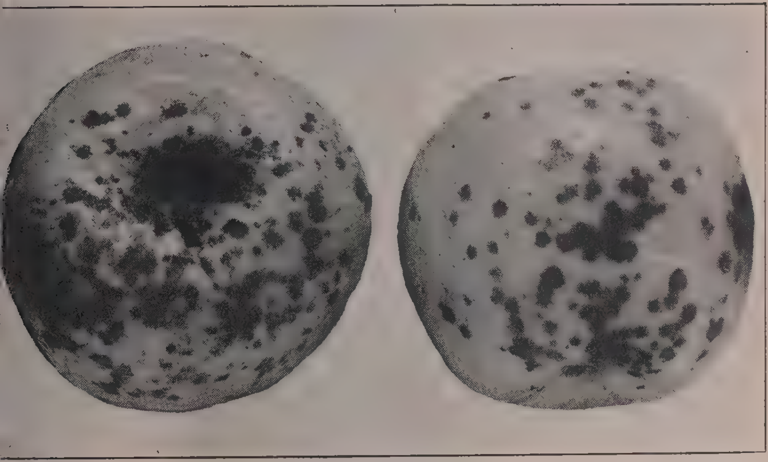


FIG. 2. R. I. Greening and Grimes apples before storage x ¾

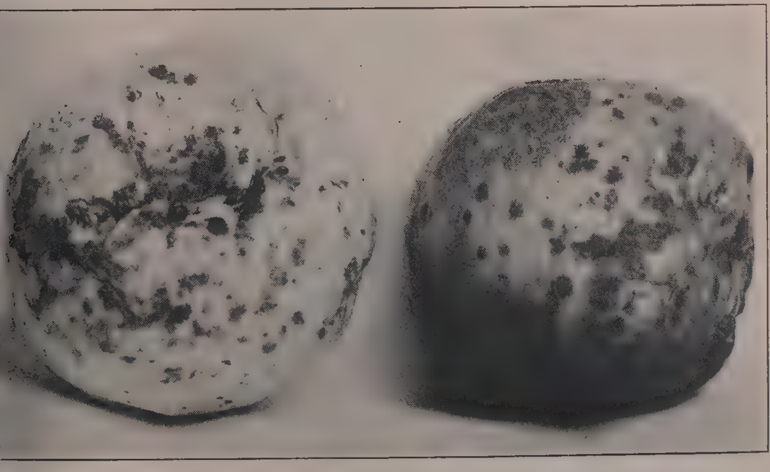


FIG. 3. Apples shown in Figure 2 after ten months in storage

control of orchard fungi, and Blair *et al.* (1916), Winn (1916), Howitt and Caesar (1917), and Pickett *et al.* (1918), are among those reporting results of various spray treatments in sooty blotch control.

*General Appearance.* Sooty blotch, as its name implies, is made up of spots or blotches, appearing to the naked eye as smears of soot, at first brown in color, darkening with age. The spots, though somewhat irregular in outline, have a tendency to be circular (Figs. 1, 2). Individual areas may vary in diameter from less than .1 cm. to .8 cm., but in most cases before the larger dimension is reached, two or more blotches will have coalesced, tending to cover the surface of the fruit.

On closer examination, sooty blotch exhibits a radiating structure of olive brown mycelial threads which extend to form a common center and branch to form a colony, fern-like in appearance.

In all essential particulars, sooty blotch, as found on stems and twigs of various hosts, is similar in appearance to that described on the fruit.

*Economic Importance.* Sooty blotch is an orchard trouble of considerable importance, in the sections of this country and Canada where it is commonly found. Otherwise high class fruit, when spotted with the fungus, is reduced materially in market value because of the disfiguration. According to Winn (1916), fruit is reduced at least one-half in selling price if sooty blotch or "cloud" is present, while Quaintance and Scott (1912) state that such blotched fruit is rendered "practically unsalable".

Wholesale apple buyers in Champaign, Illinois, inform the writer, that in the contract they make with the orchardist to buy his crop, it is expressly stipulated that no "clouded" fruit shall be packed in either the No. 1 or No. 2 grade, but must be barrelled separately, and at a discount in price of from twenty-five to fifty per cent. If the "cloudy" stock has to be discounted more than fifty per cent, it is handled only on a consignment basis.

In an examination of apples offered for sale in thirty Champaign-Urbana, Illinois, grocery stores in the fall of 1917, blotched fruit was found in nearly every case. Some of the worst appearing fruit was found in the highest class stores and vice versa. The selling price was from thirty to fifty per cent higher on clean fruit than on that heavily coated. It was evident, however, that where the trouble was comparatively mild, little attention was paid to it by the customer and still less by the dealer. The fungus is less noticeable on dark colored fruit and here seldom retards retail sale, if sooty blotch is the only blemish present.

Although a similar fungus is mentioned as being found on pears in Italy (von Thuemen 1879), nothing is known with relation to its economic importance in that country. In England, Salmon (1910), in reporting it as a new disease there, writes, "if sooty blotch becomes common * * * * it is likely to prove troublesome by damaging the look of well grown apples and thereby interfering with the practice of marketing the best apples in boxes".

Since the fungus is strictly superficial, fruit on which it is present is injured only in appearance. It has been held, (Wilcox 1905, and Hesler and Whetzel 1917), that in case sooty blotch is present, the fruit may shrivel up and permit early decay. However, with observations on hundreds of apples from Illinois, Ohio, and Alabama, stored under various conditions, there was no more shriveling on apples wholly or in part coated with the fungus, than on clean fruit.

Various opinions have been held as to the increase in size, or the spread, of sooty blotch in storage. Macoun (1906) states, that "unfortunately, the sooty fungus spreads in storage", while Salmon (1910), reports, that "it is quite clear that sooty blotch * * * * spreads on stored apples". Selby (1897), however, does not believe the fungus spreads in storage, while Sturgis (1897) finds no evidence of increase, on fruit in storage two months.

Several hundred blotches on eighty apples of different varieties, grown in various states, were carefully counted

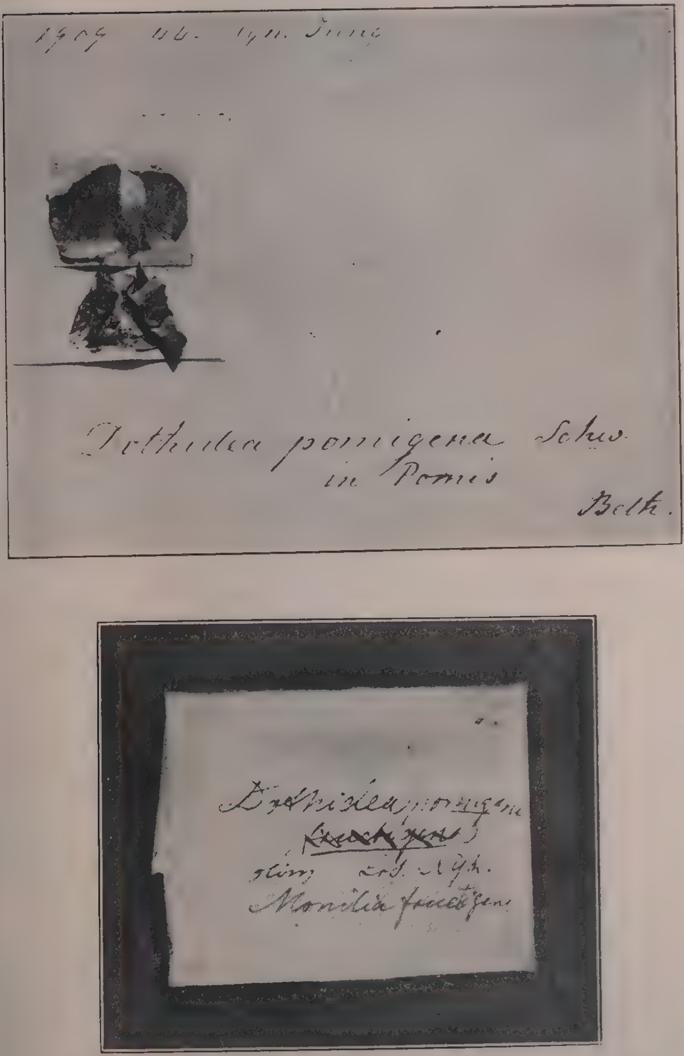



FIG. 4. Photographs of the original packet (below) and its contents (above) of Dothidea promigeua Schw. in the Herbarium of the Academy of Natural Sciences of Philadelphia.

l measured. The apples were then placed in ordinary
d storage at O° C. on October 12, 1917. Examinations
these blotches were made from time to time, but no
dence of further growth was found. The last apples
re removed from storage, August 10, 1918. Figs. 2
l 3 are from photographs of the same apples, Grimes
l Rhode Island Greening, taken before and after being
red, under the above conditions. Aside from a slight
iveling, which was noticed on the checks, as well as on
fruit bearing the fungus, no change in general ap-
arance was evident. There was no enlargement of
individual blotches.

Contrary to the statement made by Stevens and Hall
13), and Sears (1914), that sooty blotch can frequently
entirely rubbed off with a cloth, the writer has not
ind it generally true in his handling of apples from
abama, Illinois, Ohio, and New Hampshire. Boxed
oles, Winesaps, from the state of Washington, offered
sale on a fruit stand, at Champaign, Illinois, had
en polished to the usual degree found at such places.
ey were, nevertheless, markedly spotted with the fun-
s. Such facts indicate the impossibility of easily re-
ving evidence of the trouble in the orchard, through
ordinary picking and sorting operations, where can-
s gloves are worn by the workers.

*Geographical Occurrence.* Comparatively little is
own regarding the occurrence of sooty blotch, in coun-
es other than the United States and Canada. The brief
tement by von Thuemen (1879), that the fungus oc-
rs in Italy, is practically the only citation we have,
ich refers with certainty to sooty blotch on the conti-
it. In England the fungus is reported on apples by
lmon (1910), and on pears by Salmon and Wormald
15).

Macoun (1903), in reporting the presence of "sooty
igus or fly speck fungus" in Canada, states that it is
common in Ontario, but was found the previous year.
ter (Macoun 1907), he reports the trouble as usually
fined to southwestern Ontario. Howitt (1916) states

that sooty blotch is common in the Guelph (Ontario) m
ket.

In the United States, it was indicated through inf
mation in the records of the Plant Disease Survey, a
correspondence with plant pathologists of the differ
states, that with the possible exception of Georgia, so
blotch is present in every state east of the Mississi
River, as well as the entire tier of states from north
south, adjoining these Mississippi Valley states. N
braska, Kansas, Idaho, and Washington are the o
other western states to report the fungus.

*Morphology.*

*Methods.* It was found for the purpose of the pres
study that the best methods of securing suitable mou
were the following:

Sections bearing the fungus were cut as thin as p
sible, parallel to the surface of the fruit, using wh
convenient, light colored varieties. These strips of e
dermis were moistened in water, then placed cuti
downward, and carefully scraped to remove as much
the tissue as possible, killed in absolute alcohol, de
drated, cleared with xylol and mounted in Canada balsa
Some difficulty was encountered in making accurate
servations of the cell structures of the fungus, owing
some cases to the density of the epidermal cells of t
host.

Attempts to utilize the methods recommended by St
ens (1916), that of lifting off the superficial mycelium
means of a thin film of celloiden, applied and allowed
dry, were successful only on certain apples. Some str
ingly good results were obtained by this method, ho
ever, especially in removing pycnidia.

A third method was that of cutting microtome sectio
10$\mu$ in thickness, of material imbedded in paraffin. T
sections were fastened to the slide in the usual way, t
paraffin removed by xylol, the slide rinsed in alcohol a
then left in safranin stain over night. The next morni
the sections were decolorized sufficiently with acid al
hol, dehydrated, cleared, and mounted in balsam. T

. 5. Sooty blotch on pears, of the varieties, Kieffer, Clapp, and Wadleigh, x ¾

afranin stain was employed to differentiate the cuticular ayer of the host, which lies just below the fungus.

*The Thallus.* The vegetative thallus of sooty blotch is nade up of a mycelium of profusely branched hyphal hreads. The mycelium is composed of cells, olivaceous n color, according to Saccardo's "Chromotaxia" (1891), lightly constricted at the septa, usually isodiametrical n shape (Fig. 12). There is considerable variation in cell dimensions, measurements of width varying from 2-5$\mu$, and of length from 2-8$\mu$. Individual cells, groups and chains are often found with walls relatively thicker than usual, and darker in color than is typical. During the early growth of the mycelium, all the hyphal threads appear to extend in the same plane. Lateral branching is initiated very soon, however, which may result in such a profuse interlacing and crossing, that a mycelial crust results.

Several variations in the form of the thallus have been observed. In one, which appeared commonly on Rhode Island Greening apples, and which is illustrated in Fig. 2, the thallus starts from a single mycelial cell, from which, by division, three or more cells are cut off, and initiate profuse branching in many directions. Most of the cells so produced, continue to divide in their turns, at several points on their periferies, resulting in a much branched proliferation. The cells making up the main branches are prominently set off, under the microscope, by their thick walls and septa, and regular shape. They, in turn, branch laterally in both directions, often producing cells of peculiar shape (Fig. 24). Constant enlargement of the thallus by terminal growth, as well as thickening, by filling in of spaces, at first open, between the branches, results in a dense plate of closely packed, sometimes angled cells. This cell plate may occupy a small area in the center of the thallus, and measure less than 20$\mu$ in diameter. Its growth continues, however, in proportion to the proliferation of the thallus, and numerous plates have been found to measure over 720$\mu$ in diameter. The branching hyphae in all cases observed, extend out from the cell plate, the whole giving the appearance of

a fern-like colony (Fig. 7), and the type will be classified under that name.

A second type appeared rarely, and was observed only on the Huntsman apple. It somewhat resembles, under the low power, a cross-section of a honey comb (Fig. 11), and may, therefore, be referred to by that name. On examination with the oil immersion lens, however, almost hyaline hyphal threads, in some instances with hardly distinguishable septa, were observed, branching irregularly over the areas included in the honey comb like cell aggregations. The latter, on their part, are composed of sometimes short, many septate hyphae; sometimes masses of cells, irregularly grouped and bounded, but with cell walls and septa thicker and darker, and with denser cell contents, than of the hyphae in the more open spaces. The cells of this type measure 2-3 x 2-5$\mu$, being in many instances longer than broad.

A third thallus type (Fig. 12), which may be named the reticulate type, is characterized by a very large number of long, tenuous branches, gradually radiating from a common center. In general, the cells are 2-4 x 2-5$\mu$, and commonly regular in shape. No peculiarities in budding were noted such as were cited for the first type. Definite anastomosis of cells originating from the hyphal branches which lie more or less parallel, coupled with this regular branching, are characteristic of the type. Branches, composed of two and three hyphal rows closely appressed, were commonly noted.

In the first stages of development of all thallus types the hyphal threads appear to extend in the same plane. Within a short time, however, there is noted a tendency to form cell aggregations, or a piling up of cells. This results in the formation of large numbers of minute black specks (Fig. 18), generally invisible to the naked eye, and usually not more than 100$\mu$ in diameter, interspersed among the mycelial threads. These are not to be confused with the cell aggregations making up the so called fly specks (Fig. 18), however, which are much larger, up to 270$\mu$ in diameter, and much less numerous when present at all. On the other hand, the minute

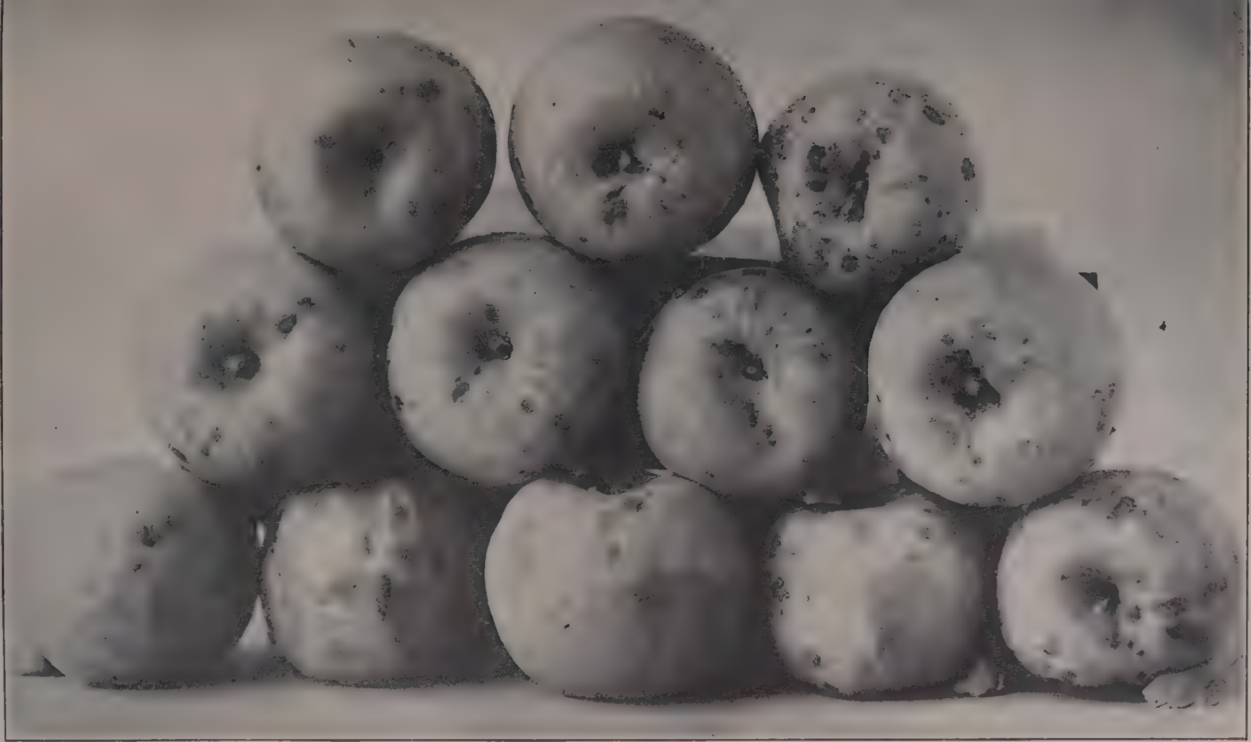


Fig. 6A. Grimes apples affected with sooty blotch, before immersion in Javelle water

specks are cell formations, which have to do with reproduction, and will be discussed under the next heading.

A cross section of the blotch mycelium (Fig. 33), shows its superficial nature, and the characteristically irregular looping and interlacing of the hyphal threads, some of which are darker in color than the others.

*Pycnidia.* The pycnidia are scattered throughout the thallus. Though often indistinct to the naked eye, they are easily discernable, individually, with a magnification of ten diameters. They are usually found to be separate, though occasionally two or three are so closely pressed together as to appear united. Their presence intensifies the dark, almost black, appearance of the blotched areas. On apple fruit they are often very numerous, averaging about 1,000 per square centimeter. This number is considerably greater than the corresponding one for the same unit of area on apple bark. Mature spore-bearing pycnidia were very rarely found.

Typical pycnidia (Figs. 10, 13) measure, when mature, about 20-40$\mu$ in thickness, and 70-100$\mu$ in diameter, and are dimidiate, i. e., as seen from above, they present an approximately circular contour; in cross section they are found to be flattened at the base and with a top uniformly rounded.

They appear under the high power as closely tangled, dense, reticulate masses of fine mycelial threads, with hyphae extending away in several directions (Fig. 30). No ostiole has been observed, its purpose being served by an aperture of a different nature, the opening of which begins with the appearance of a pale spot at or near the central region of the pycnidium. Later stages show the breaking down of the cells in this region, then one or more cracks appear, and fragments drop out, leaving a large, more or less jagged opening (Fig. 22).

Within the pycnidium are borne conidia with paraphyses. The tissue, of which the interior of the pycnidium is composed, is gelatinous, as are the conidia and paraphyses, which are separated with difficulty after being forced from the pycnidium (Fig. 21).

In the accompanying diagram (Fig. 34), are shown i cross section, the relative positions of the various part of the pycnidium. The pycnidium (a), is seen to be en tirely above the cuticle (b), and to possess a solitar subglobose locule (e). The mycelium (f) leading up t the pycnidium proper, is extremely dense, and it is se dom that its cellular structure can be recognized. It ap proaches the locule from either side, the locule being i a way buttressed by the ends of the former. The locul itself is surrounded by cells of irregular shape (d) somewhat gelatinous in character, and thinner walled an lighter in color than those of the thallus (f), individua cells in the inner layer alone, being recognizable. Cellu lar structure of this nature extends above the locul making up the upper layer (c) of the pycnidium. In th angles (g), made betwen the buttressing mycelium an the locule, as well as along the base of the pycnidium jus below the locule, the cells are still lighter in color tha those immediately above the locule.

*Pycnidial Formation.* According to DeBary (1884 and Kempton (1919), pycnidia may arise by one of tw methods, which they designate as "symphogenous" an "meristogenous": "symphogenous" when the youn hyphal threads interlace to form at first a loose networ later one gnarled and knotlike, "meristogenous" whe the pycnidial primordium arises by intercalary growt on one or more cells of one hyphal branch. Variation in these two methods have also been noted, such as simp and compound modes of each, or even a combination the two methods.

The various stages in pycnidial formation in soot blotch, have been followed on apple skin by mountin representative bits at different times in the year. Pycn dial development was observed to be in progress in Se tember, but it is not usually complete until the winter over, and appears to proceed naturally on material wi tering out of doors.

Pycnidial formation in sooty blotch is usually sym phogenous (Figs. 27-30), though the behavior of th

Fig. 6B. Grimes apples affected with sooty blotch, after immersion in Javelle water

hyphal threads is variable and examples may be found of different modes.

In one developmental series, representative of the symphogenous method, formation of the pycnidial primordium begins by the lateral budding of one or more cells of a hyphal thread (Fig. 28), cells of various shapes and sizes being cut off. A second hypha, lying beside the first, buds, and the branches resulting from these two parent hyphae unite. In other cases, this second hypha is included in the formation, by the uniting of a branch of the first hypha with a cell of the second (Fig. 27). Occasionally, additional main mycelial threads may become involved.

From this stage on, regardless of how initiated, the process is one of rapid branching, with many connecting links formed between the hyphal threads (Fig. 29). Much looping and interlacing of main and branching hyphae ensues, which results in a dense mass of mycelial cells. The outer portion or covering then becomes membraneous and darkens in color. Further internal development and cell differentiation of the mass, results in a pycnidium (Fig. 30).

*Conidia.* Conidia were rarely found, as scores of seemingly mature pycnidia were examined without evidence of fructification. The method of procedure was as follows: Bits of apple skin on which it was thought good material might be present were placed in concentrated potassium hydroxide over night. The next morning the skin was washed and the pycnidia removed to a glass slide, in a small amount of water. A cover glass was placed on the material, and individual pycnidia observed under the low power, were forced open by careful pressure with the scalpel. Where conidia were observed extruding through the characteristic slit, they were stained with iodine.

The conidia (Figs. 23, 31), are almost hyaline, one-celled, and while varying in shape, are somewhat oblong, straight or slightly curved, muticate, measuring 10-20 x 4-7$\mu$. The conidia appear to be sessile, or borne

on very short conidiophores arising as lateral branches from the mycelium, which forms the base of the sporogenous structure.

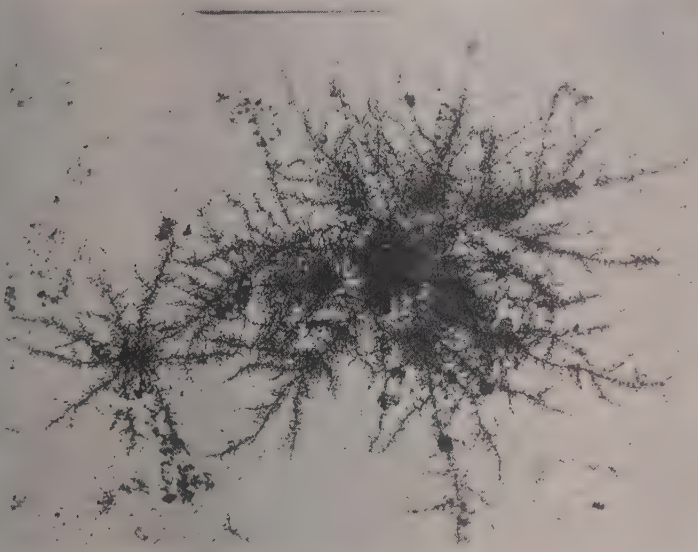
*Paraphyses.* A fact of importance to be noted is the presence of copious paraphyses (Figs. 23, 32). They are slender, blunt, gelatinous, and many-septate, and extend among and far beyond the conidiospores. In various genera of the perfect fungi, the presence or absence, and the shape and size of paraphyses are important characters in differentiating these genera. Such structures are very much less common in the imperfect fungi and are here rarely used as generic characters.

However, Saccardo, in the "Sylloge Fungorum" uses the presence of paraphyses as a generic character in limiting *Lasiodiplodia,* and he also describes paraphyses in connection with many species of *Chaetodiplodia.* Higgins (1916), in his discussion of the nomenclature of plum wilt, which he places in the genus *Lasiodiplodia,* states that "the presence of paraphyses seems to be the most constant character of the pycnidia".

*Chlamydospores.* What appear to be chlamydospores have been observed often in examination of thalli of the fern-like type (Fig. 7). These spore-like bodies may be described as dark brown, thick walled, sometimes angled cells. They probably originate through the breaking apart of single cells of mycelium. It is certain that these chlamydospores initiate new colonies, since in thalli containing but 4-7 cells (Fig. 26), as well as in those much larger (Fig. 24), the chlamydospores are still easily recognizable near the center of the thallus.

*Histological Relation.* Sections of apple and pear fruits, more or less coated with sooty blotch, after being stained with the safranin, showed clearly that the statement generally made, affirming the superficial nature of the fungus, is correct. In no case was the cuticle penetrated, or any of the epidermal cells or those below, disturbed, or their appearance altered from the normal, when sooty blotch was present. This fact is well illustrated with respect to the pear, in Fig. 14, and the apple,

PLATE I



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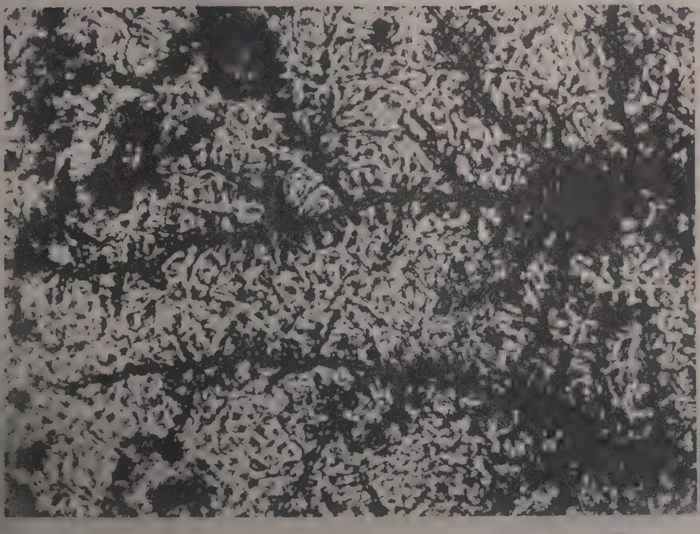


in Figs. 13 and 15, as well as in Fig. 34, previously discussed, where the relative position of the pycnidium to the cuticle is shown.

These observations are of interest, also, in another connection. According to Beach (1899), Clinton (1901), Lamson (1903), and Salmon (1910), sooty blotch, on superficial examination, has often been mistaken for apple scab. Since apple scab is subepidermal, a cross section of an apple fruit affected with scab would show a true diseased condition of the host, which condition is entirely lacking where sooty blotch, alone, is present.

*Taxonomy.* In 1832[2], Schweinitz published the species *Dothidea pomigena,* under the section Asteroma, the description reading as follows:

"1909 *D. pomigena* L. v. S., frequens in maturis Pomis dictis "Newtown Pippins". Pennsylv.

"*D. pomigena* maculis orbiculatis laxis, e fibrillulis tenerrimis nigris reticulato radiantibus, plerumque sterilibus. Cellulis in centro aggregatis, applanatis majusculis. Maculis vix unquam ¼ uncialibus."

The original specimen is now in the Schweinitz collection, in the Herbarium of the Academy of Natural Sciences of Philadelphia, Pennsylvania. Both the packet and its contents were kindly photographed by Dr. J. W. Harshberger, and appear as Fig. 4.

It will be noted that Schweinitz was uncertain as to the name to apply to the fungus, in that he first labelled the packet *Dothidea fructigena,* then changed it to *D. pomigena.* The packet also states that the fungus was formerly known as *Monilia fructigena.*

It is not clear why Schweinitz placed the fungus in Dothidea, a genus with the stromata formed within the tissues of the host plant, and later becoming erumpent.

[2] Some question has arisen as to the year of publication, Sturgis (1898) stating it to be 1831, while Clinton (1901) gives it 1834. The matter is cleared up by the following statement in a recent letter to the writer, from Dr. J. H. Barnhart, Bibliographer of the New York Botanical Garden: "The paper by Schweinitz, "Synopsis fungorum in America boreali media degentium", was published in 1832, not 1834 (see North American Flora, vol. 9, page 451). The volume title-page is dated 1834, but this paper constitutes Part 2 of the volume, dated 1832 (I have seen several copies in their original covers) and there is no doubt that it was issued in that year."

It is certain, however, that the fungus of Schweinitz is what we now know as sooty blotch. Sturgis (1898) translates Schweinitz' description of *D. pomigena* as follows: "Spots orbicular, loose, (in texture?) (composed of) a radiating network of very delicate black fibrils, for the most part sterile. Cells in the center aggregated, expanded, comparatively large. Spots hardly over ¼ inch (in diameter). Common on ripe apples known as 'Newtown Pippins', Pennsylvania;" and concludes that "the sooty disease * * * * is probably identical with the fungus observed by de Schweinitz on Newtown Pippins".

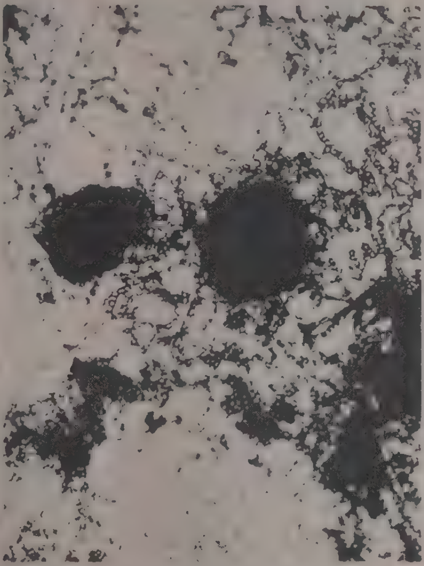
Clinton (1901) in his study of apple scab, after an examination of Schweinitz' original specimen of *D. pomigena,* concludes it is not scab as some botanists have suspected, "being more like the fly speck fungus in its macroscopic appearance". Clinton's statement has misled many succeeding investigators who have reasoned that *Dothidea pomigena* Schw., later changed to *Phyllachora pomigena* by Saccardo, (1883) is indeed fly speck. The writer was not convinced as to this fact and correspondence brought out the following: Clinton in a recent letter[3] states with regard to *Dothidea pomigena,* "What I wished to satisfy myself of at the time, was that it was not apple scab. I am not sure that at that time I had a very distinct idea of sooty blotch so may have thought it resembled the fly-speck fungus because I did not distinguish between them".

In a letter[4] from Harshberger, he states after an examination of *D. pomigena* Schw., at Philadelphia, that the fungus is in all probability sooty blotch, rather than fly speck, since the areas are diffused and there are no specks.

Since Schweinitz included *D. pomigena* under the section Asteroma as he understood it, (cf. original description), Sprague (1856) lists sooty blotch as *Asteroma pomigena* Schw., among a number of fungi collected near Boston and named by M. A. Curtis. Later in the same year, Sprague (1856) describes, with a specimen, the

[3] Letter of April 14, 1919.
[4] Letter of March 14, 1919.

PLATE II



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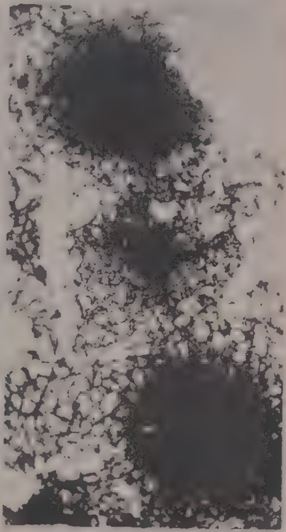

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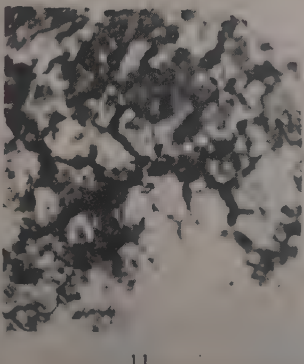

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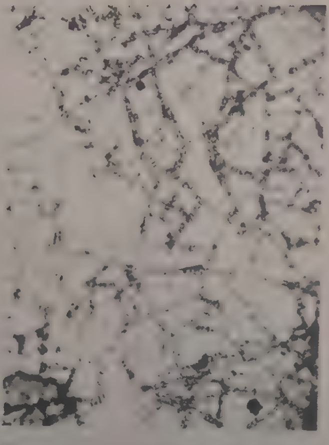

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sooty blotch fungus, using the same name as before, *Asteroma pomigena* Schw. He mentions the presence of minute black perithecia seated upon the mycelium, though he was not able to find any evidence of spores.

Saccardo (1893), after giving Schweinitz' Latin description of *D. pomigena*, renames the fungus, which thus becomes *Phyllachora pomigena* (Schw.) Sacc. The reason for this transfer is not clear, since Phyllachora has a well defined stroma within the host tissues, a character which is entirely lacking in sooty blotch. No evidence of the existence of ascospores of *P. pomigena* (Schw.) Sacc. is on record. Furthermore, Theissen and Sydow (1915), in their monograph on the Dothideales, list *Phyllachora pomigena* (Schw.) Sacc. under "Species Phyllachorae delendae".

Montagne and Fries (1834), published the species *Labrella Pomi*. Although the description is meager and not conclusive, it probably refers to fly speck.[5] Saccardo (1879), after repeating the description of Montagne and Fries, renames the fungus "*Leptothyrium? Pomi*", although he reports no spores. Later, Saccardo (1884) lists this fungus as "*Leptothyrium Pomi* (Mont. et Fr.) Sacc."

The name *L. Pomi* as above is commonly found in the literature to refer to fly speck, until Selby (1900) published "Sooty Fungus and Fly-speck Fungus * * * * *Leptothyrium pomi* (Mont. et Fr.) Sacc." He thus was the first to group the two fungi under the same technical name.

Selby mentions no investigations to prove the identity of the two fungi. The nearest approach to work of this nature was that done by Floyd, and reported by Duggar

[5] Since the above was written, positive evidence has come to light which substantiates the writer's statement. Through the kind offices of Doctor Wm. Trelease, Head of the Department of Botany, University of Illinois, three mounts were prepared from Montagne and Fries' No. 847, preserved in the Montagne Herbarium in the Museum of Natural History in Paris. The Curator of the Museum kindly sent the mounts to Doctor Trelease, who turned them over to the writer for study. The tissues are somewhat tangled as the material was cut free hand, nevertheless, the characteristic structure of fly speck is clearly evident. The mounts have been forwarded to Doctor J. W. Harshberger to be placed in the Herbarium of the Academy of Natural Sciences of Philadelphia.

(1909), who states that "the sooty blotch and fly speck are apparently stages of the same fungus" and provisionally refers to them as one fungus, though the evidence on which he bases his conclusions is not presented.

Since the publication of Duggar's book (1909), *Leptothyrium Pomi* (Mont. et Fr.) Sacc. has been quite generally accepted as the technical name for the two fungi, though this usage is not universal. In a recent letter,[6] G. R. Lyman of the U. S. Dept. of Agriculture, Plant Disease Survey, states that most of their collaborators refer to *Leptothyrium Pomi* (Mont. et Fr.) Sacc., as the cause of sooty blotch, and a smaller number attribute fly speck to this fungus. Sheldon, Cook, and Clinton refer to *Phyllachora pomigena* (Schw.) Sacc., as the cause of sooty blotch.

The following herbarium specimens were examined. The label on the packet is given as well as the herbarium or set of exsiccati from which the specimen was received. In the column headed "sooty blotch" are placed the names of the specimens classified by the writer as such: in the column "fly speck" are placed those classified by him under that name.

### SOOTY BLOTCH

*Phyllachora pomigena* Schw. Sacc. Pirus malus. Winchester, Va. Oct. 21, 1908. Com. M. B. Waite. Det. M. B. Waite. From U. S. Dept. of Agr.

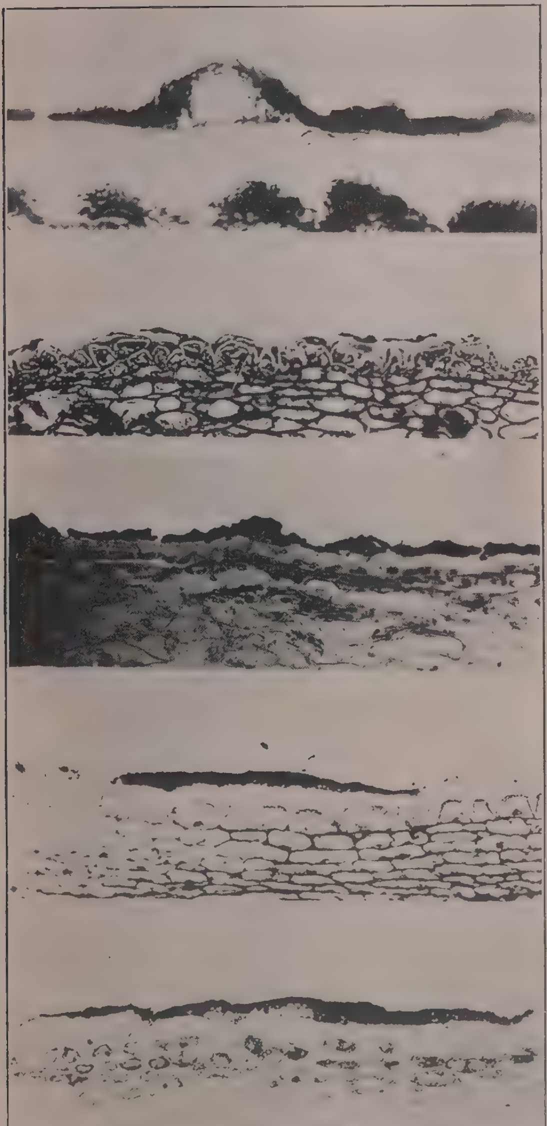
*Phyllachora pomigena* (Schw.) Sacc. From Giltner in Hamilton Co. Collector Mrs. E. D. Snider, 22 Sept. 1909. Herbarium of Plant Pathology, Dept. of Agricultural Botany. Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

### FLY SPECK

Disease of Malus malus "Genitan". Caused by *Leptothyrium pomi.* From Red Cloud. Collector J. M. Bates, Jan. 31, 1908. Herbarium of Plant Pathology, Dept. of Agricultural Botany, Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

[6] Letter of March 10, 1919.

PLATE III



*Leptothyrium Pomi,* Mont. & Fr. Pirus malus. W. Va., Mar. 24, 1909. Comm. L. C. Corbett, Det. M. B. Waite. From U. S. Dept. of Agr.

Disease of Malus malus. Caused by *Leptothyrium pomi* (Mont. & Fr.) Sacc. From Giltner in Hamilton Co. Collector Mrs. E. D. Snider, 22 Sept. 1909. Herbarium of Plant Pathology, Dept. of Agricultural Botany, Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

Ellis & Everhart. North American Fungi. Second Series. 2174 *Leptothyrium Pomi* (Mont. et Fr.) On apple skins. Chicago, Ill. Col. W. W. Calkins, Univ. of Ill. Herb.

de Thuemen Mycotheca universalis 1483 *Labrella Pomi* Mntg. et Fries in Ann. sc. natur. 1843. I. p. 347. Mntg. Syll. plant. cryptog p. 272. Autria inferior: Wien in Pyri Mali Lin. fructibus servatis. Apr. 1879, leg de Thuemen. Univ. of Ill. Herb.

C. Romeguere. Fungi selecti exsiccati 6357 *Leptothyrium Pomi* (Mont. et Fr.) Sacc. Syll. Ill., p. 632; *Labrella Pomi,* Mont. Grognot, flore de Saone et-Loire, p. 136 f Crataegi.

Sur fruits de Crataegus oxyacantha mars 1893. F. Fautrey. Univ. of Ill. Herb.

In view of the morphology of the sooty blotch fungus, as described on the previous pages, it is obvious that it does not belong to any of the genera just discussed, and, moreover, that it possesses characters sufficiently striking and distinctive to warrant the erection of a new genus to receive it. For this I propose the name *Gloeodes,* gelatinous, referring to the gelatinous interior of the pycnidium, with the following generic description: *Gloeodes* nov. gen.

Mycelium strictly superficial, dark colored, septate, profusely branched, often anastomosing, constituting a thallus, often fern-like in appearance but occasionally of other types; pycnidia dimidiate, membrano-carbonous, interior gelatinous; paraphyses present; conidia oblong, one-celled, hyaline.

The type of the genus is

*Gloeodes pomigena* (Schw.) nov. comb.

*Dothidea pomigena* Schw., Trans. Am. Phil. Soc. n. s. *4*:232, 1832.

*Asteroma pomigena* (Schw.) fide Curt. in Sprague, Proc. Boston Soc. Nat. Hist. *5*:325, 1856.

*Phyllachora pomigena* (Schw.) Sacc., Syll. Fung. *2*:622, 1883.

*Leptothyrium Pomi* Selby, Ohio Agr. Exp. Sta. Bul. 121:12, 1900, as to sooty blotch only, the original idea of *L. Pomi* having reference to the fly speck fungus alone.

Pycnidia dark brown, dimidiate, scattered or aggregated, superficial, rupturing irregularly; conidia oblong, sometimes slightly curved, one-celled, hyaline, 10-20 x 4-7$\mu$; conidiophores short or lacking; paraphyses septate, gelatinous, slender, blunt, longer than the conidia.

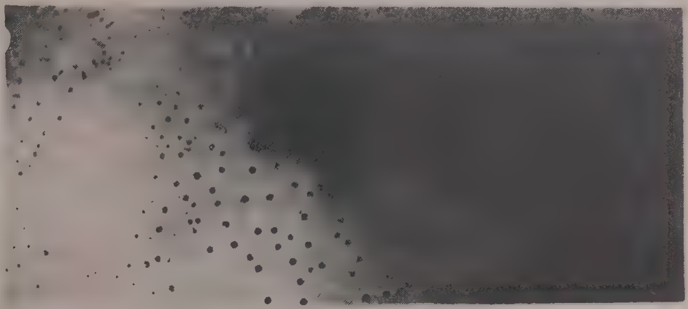
Hab. fruits and stems of certain species of Pyrus.

*Host Considerations.* Sooty blotch of pomaceous fruits is very common on the apple, Pyrus Malus L. (Fig. 2), appearing less often on the pear, Pyrus communis L. (Fig. 5). The literature available does not record with certainty, the occurrence of sooty blotch on any other hosts. Duggar (1909) reports what was either sooty blotch or fly speck on trees and shrubs other than pomaceous ones, though he does not mention any host plant by name, nor does he distinguish between sooty blotch and fly speck, because he regarded them as identical.

The writer has observed a sooty blotch on the twigs or stems of peach, Prunus Persica (L) Stokes, and blackberry, Rubus nigrobaccus B. (Fig. 19), both of the family Rosaceae, and on black mustard, Brassica nigra (L) Koch. (Fig. 20), of the family Cruciferae.

Various authorities regard the Rhode Island Greening, Peck's Pleasant, Rome, Baldwin, and Northern Spy apples, and Anjou, Lawrence, and Kieffer pears as those on which the fungus is most commonly found in North America. English writers report the Newton Wonder apple and Catillac pear, as most frequently bearing the

PLATE IV



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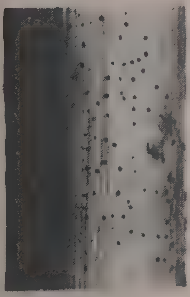

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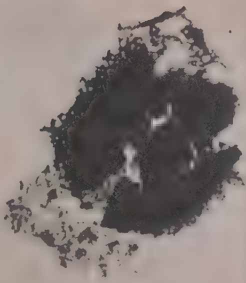

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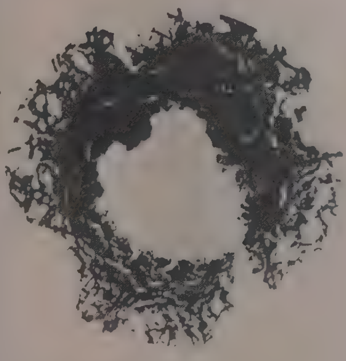

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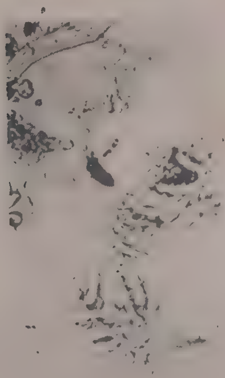

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fungus. However, it has been the writer's experience in dealing with sooty blotch, that in a season of considerable rainfall during the late summer, especially in orchards poorly pruned, the trouble was generally present on the fruit of nearly all varieties. For example, in one Illinois orchard in 1917, he found sooty blotch on the fruit from practically every tree and secured material from apples of twelve varieties, which are not specifically mentioned in the literature as those on which the fungus appears.

## III. CONTROL

Sooty blotch, being superficial, comparatively slow growing, and appearing rather late in the season, is commonly well controlled in orchards properly located as regards air and water drainage, where correct methods of orchard management are followed.

On the other hand, it is practically impossible to exclude it from orchards, on sites poorly located (Howitt 1911). Fletcher (1912), Selby (1900), and Sheldon (1905) recommend the selection of an elevated site, where the trees will secure sufficient air and sunshine. In Illinois, in 1916, 1917, and 1918, according to my own observations, the trouble was much more commonly found in unpruned than in pruned orchards, and in vigorous young trees than in older more open-headed ones. The year 1917 was comparatively rainy during the latter part of the growing season. The conditions were reversed during 1918. Orchards under observation at Farmingdale and Clinton, Illinois, fairly well pruned to admit sunshine and air, and located on elevated sites, were not sprayed for the control of fungi in 1918. Scab *(Venturia inaequalis)*, blotch *(Phyllosticta solitaria)*, and black rot (*Physalospora Cydoniae*) were common. Not an apple, however, was found with sooty blotch. In the Farmingdale orchard, moreover, during the previous year, which was one of moderate rainfall during the latter part of the growing season, the trouble had been found wide-spread and abundant. It thus appears that the

fungus is extremely susceptible to unfavorable environmental conditions.

Proper pruning is important in preventing the occurrence of sooty blotch in fruit trees. Opening the trees to sunshine and air should be the first measure taken to combat the trouble.

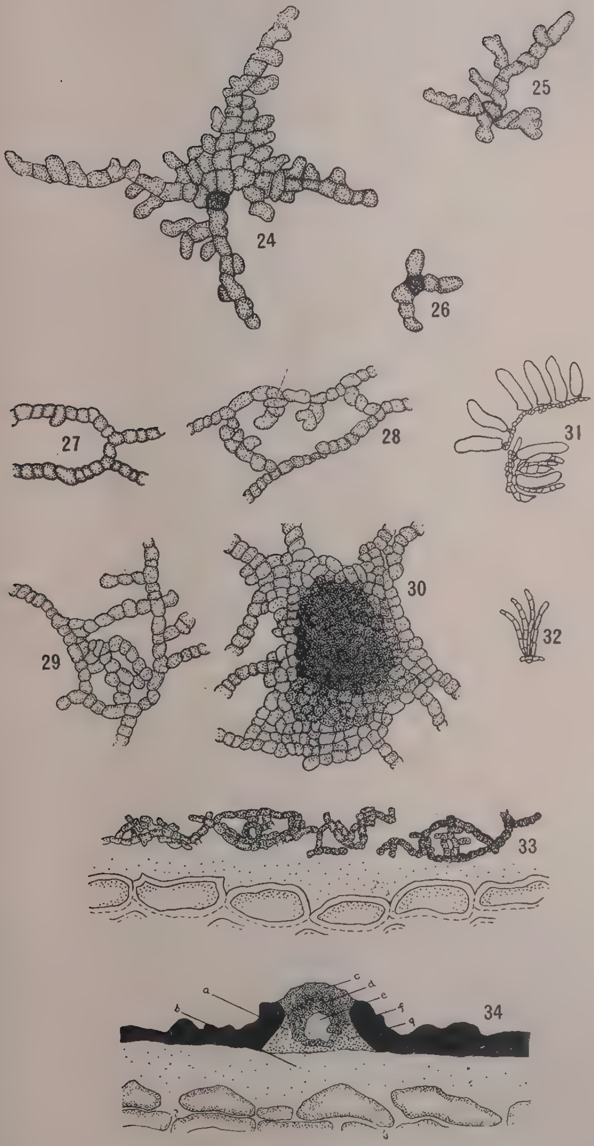
Clinton (1906) reports the sooty blotch as noticeably injurious in Connecticut orchards, "even where they have been sprayed". With this exception, the fungus has generally been reported easy of control when a regular spray schedule was followed. Usually this control comes about as an incidental result (Scott 1906, and Beach 1912), of other applications of spray material in the schedule.

The first recorded experimental work carried on for the control of sooty blotch was that of Lamson, on pears (1894). He reports that spraying with Bordeaux mixture was effective in controlling the trouble. His formula was 6 lbs. copper sulfate, 4 lbs. lime, in 22 gallons of water. Lamson's results, of special value in showing gradations of control, are tabulated as follows:

| | Free from spot | Slightly spotted | Badly spotted |
|---|---|---|---|
| Unsprayed .................. | 18% | 57% | 25% |
| Sprayed ..................... | 77% | 23% | 0% |

Since that time, coincident with the gradual improvement in the formula for Bordeaux mixture, and more knowledge of its limitations, as well as advantages, in sooty blotch control, other fungicides have been discovered and tested. Lamson (1903), with a 5-5-50 Bordeaux mixture, reports that in spraying apples for scab, primarily, 77% of the fruit harvested was free from sooty blotch, 23% slightly spotted, and none badly spotted. Selby (1906) suggests an application of 4-4-50 Bordeaux mixture when the apples are the size of hickory nuts. An exception is made in case of apples like the Maiden Blush and Grimes varieties, when the spray should be applied earlier to avoid russetting the fruit. Norton and Seymour (1907) recommend Bordeaux mixture when the

PLATE V



fruit is one quarter grown. Stevens (1910) urges the adoption of a regular spray schedule of six applications, using Bordeaux mixture.

It may sometimes be necessary, in severe cases, augmented by rainy weather in late summer, to make more than the usual number of fungicidal applications. Wilcox (1905) believes that control of sooty blotch will be insured by spraying against apple scab, supplemented by one or more applications in July, a program also urged by Rolfs (1907). Howitt and Caesar (1917) recommend the application of the regular scab sprays early in the season, using lime sulfur as the fungicide. These are to be followed by an early August application, especially for sooty blotch control. Coons and Nelson (1918) state that it is often the practice in Michigan to use Bordeaux mixture late in July or up to the middle of August, as a supplement to the regular lime sulfur sprays.

It is worthy of note in this connection that Clinton and Britton (1912), and Blair *et al.* (1916), have found arsenate of lead to be of some fungicidal value, since it is slightly effective in sooty blotch control.

Some work has recently been done with a view to testing the relative effectiveness of the two standard fungicides, lime sulfur and Bordeaux mixture, in the control of sooty blotch. Ballou (1912) states that in Ohio the trouble was thoroughly controlled with one application of lime sulfur, the spraying being done late in July. He also shows that this material was as effective as Bordeaux mixture. Blair *et al.* (1916) report Bordeaux mixture superior to lime sulfur. They show in addition, that lime sulfur with arsenate of lead added, was slightly superior to lime sulfur alone, but adding arsenate of lead to Bordeaux mixture did not increase its fungicidal effect. Pickett *et al.* (1918) state that both Bordeaux mixture and lime sulfur, when used separately, completely controlled sooty blotch in 1913 and 1914, while as high as 25% infection was found in the check plots.

## IV. GENERAL DISCUSSION

It has been shown that the names sooty blotch and fly speck have been confounded, and some authors have held that the two are but different forms of the same fungus. The morphological studies so far carried on by the writer, however, do not enable him to regard the sooty blotch and fly speck as caused by the same fungi, for the following reasons:

On many apples, collected at various times of the year, from Illinois and other states, showing a large amount of sooty blotch, no fly speck was present (Frontispiece).

It has often been observed, that where colonies or thalli of the fly speck and sooty blotch fungi approach each other, one of these fungi exerts an inhibiting or retarding effect upon the growth of the other, so that, for example, a nearly circular colony of the fly speck fungus may be almost completely surrounded by sooty blotch, yet the line of demarkation between the two be sharp and clearly marked (Fig. 18).

In other instances, a colony of one of the two fungi may grow toward a colony of the other fungus, until the two meet, then one may proceed to surround the other but not to grow into it. The condition exhibited is much like that frequently found on agar plates, where colonies of fungi or bacteria inhibit the growth of each other, and constitutes a strong argument that fungi which can so inhibit growth of each other are not of the same species. While this inhibition or antagonism of sooty blotch by fly speck or *vice versa* is a very common phenomenon, cases do frequently occur where one of these fungi grows into the colony of the other, such as Rhizopus may grow through a colony of Penicillium.

The morphology of the cell aggregations of sooty blotch and fly speck is dissimilar as to the size and external appearance (Fig. 18), and internal appearance (Figs. 15, 17).

The mycelium radiating from the cell aggregations of sooty blotch (Fig. 9), has been discussed. The mycelium radiating from the fly speck is very fine and hyaline, and is of quite different character than that of sooty blotch.

Finally, there has been observed a marked difference in the geographical range of the two fungi, by the writer and others. J. H. Gourley[7] of New Hampshire, in a letter to the writer, states: "It has been very apparent to me since being in this country that the fly speck does not develop as much as it did out in Ohio."

In view of these several points of evidence as to the independence of sooty blotch and fly speck, and the fact that their general aspect is quite dissimilar, any assumption of their identity would be quite gratuitous. The burden of proof must rest with any who make such an assumption.

While the writer has made no studies, as yet, as to the dissemination of sooty blotch, except the observation regarding the presence of chlamydospores, it was noted on examination of hundreds of apples of many varieties, from various parts of the United States, that in a very large percent (80-90) of cases, the fruit showed more sooty blotch at the stem end (Frontispiece), than elsewhere. This fact is presumably correlated with the dissemination of chlamydospores, by air, during the latter part of the growing season.

It was found that sooty blotch could be easily removed, with no damage to the apples, by immersing them for three to six minutes in Javelle water. The apples were then well washed and rinsed in running water and allowed to dry. The formula used in preparing Javelle water is as follows:

JAVELLE WATER

| | |
|---|---|
| Bicarbonate of soda | 4 lb. |
| Chloride of lime | 1 lb. |

Put soda in kettle over fire, add 1 gallon boiling water, let boil 10-15 minutes, then stir in the chloride of lime, so as to avoid the formation of lumps. Use when cool. The sodium hypochlorite is the effective reagent in destroying the fungus, by oxidation. It is believed that a practicable method can be developed, commercially, to enhance the sale price of blotched fruit, by removing the fungus.

[7] Letter of November 6, 1918.

In the literature, the sooty blotch fungus as observed on apple and pear fruits, is held to be morphologically similar with the exception of Salmon and Wormald's (1916) report. They state, after a description of sooty blotch on apples, in England, that its appearance on pears is very much the same, except that on apples there are very numerous "minute black specks". It is very likely that the sooty blotch, as Salmon and Wormald observed it, was a comparatively young stage, since in studying the trouble in Illinois on several varieties of pears, it was noted that the very small black "specks" primordia of pycnidia, did not begin to appear until October. This was about the same time that similar "specks" were forming on apples.

Martin (1918) describes "Brown Blotch of the Kieffer Pear", which he believes is probably closely related to the sooty blotch fungus, but is distinguished by its smaller size, its straighter connecting strands, and that it burrows into the cuticle, causing hypertrophy of the subcuticular layers. It is clearly evident that the disease Martin describes is not caused by the same fungus the writer has treated in these pages.

## V. SUMMARY

1. Sooty blotch is a common trouble of apples and pears, of considerable economic importance, in North America and England.

2. It is entirely superficial, and does not cause rot or bring about any perceptible host malformation.

3. It was found on all varieties of apples examined, when conditions were favorable for the fungus.

4. Three thallus types have been observed, the fern-like type (Fig. 7), the honey comb type (Fig. 11), and the reticulate type (Fig. 12).

5. Pycnidial development is commonly by the symphogenous method (Figs. 27-30).

6. The fungus has been known as:

*Dothidea pomigena* Schw.

*Asteroma pomigena* (Schw.) fide Curt. in Sprague.

*Phyllachora pomigena* (Schw.) Sacc.
*Leptothyrium Pomi* Selby.

but does not belong to any of these.

7. Its characters warrant the erection of a new genus.

8. For this the name *Gloeodes* is proposed.

9. The names fly speck and sooty blotch have been commonly confounded, and some have held that the two merely represent forms of one fungus. The evidence is opposed to this view and the two should be regarded as separate fungi, unless full proof that they are connected can be adduced.

10. Arguments against the fly speck and sooty blotch being identical are: (a) the two are frequently found separate; (b) an antagonism often appears to exist between the two, as a sharp line of demarkation is observed when their colonies approach each other; (c) the morphology of the cell aggregations is dissimilar; (d) the mycelium radiating from the cell aggregations is dissimilar; (e) there is a marked difference in geographical range of the two fungi.

11. Sooty blotch is controlled by correct orchard management.

12. The fungus does not spread appreciably in storage.

13. Sooty blotch was easily removed from the surface of apple fruits after immersion in Javelle water for a short time.

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Saccardo, P. A.

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Thuemen, F.

1879. Labrella Pomi Mntg. *In* Fungi Pomicoli, p. 118-119, Wein.

Describes fungus in Latin and lists others in synonymy. Describes and figures spores as globular.

Thuemen, F.

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Saccardo, P. A.

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Selby, A. D.

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Sturgis, W. C.

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1899. Sooty Blotch. *Phyllachora pomigena* (Schw.) Sacc.) Fly Speck. *Leptothyrium pomi* (Mont. & Fr.) *In* Common Diseases and Insects Injurious to Fruits. N. Y. (Geneva) Exp. Sta. Bul. 170, p. 383-388.
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Selby, A. D.

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Clinton, G. P.

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Brief descriptive notes.

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Longyear, B. O.
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Sheldon, J. L.
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Sooty Blotch. *Phyllachora pomigena* Schw. Sacc.)
*In* Fruit Tree Diseases and Fungicides. Mo. State Fruit Exp. Sta. Bul. 16, p. 8.
Brief descriptive notes of the "diseases" on apples. Pears are also affected. Control measures recommended.

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Hewitt, J. L., and Hayhurst, P.

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Howitt, J. E.

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Brief descriptive notes. Bordeaux mixture when apples size of hickory nuts recommended in control.

Ballou, F. H.

1912. The Rejuvenation of Orchards. Ohio Agr. Exp. Sta. Bul. 240, p. 511.

Sooty fungus controlled with lime-sulfur or Bordeaux mixture applied late in July.

Beach, S. A.

1912. Sooty Blotch. Fly Speck. *In* Spraying Practice for Orchard and Garden. Iowa Agr. Exp. Sta. Bul. 127, p. 52-53, 61-62.

Spray schedule for control.

Brooks, Chas.

1912. Sooty Blotch and Fly Speck. *Leptothyrium pomi*. *In* Some Apple Diseases and Their Treatment. N. H. Agr. Exp. Sta. Bul. 157, p. 15, fig. 17.

Dependent on moist weather for development. Readily controlled by spraying and pruning.

Clinton, G. P., and Britton, W. E.

1912. Tests of Summer Sprays on Apples, Peaches, etc. Conn. Agr. Exp. Sta. Rpt. 1911, p. 357.

Lead arsenate used alone gave noticeable control.

Quaintance, A. L., and Scott, W. M.

1912. Sooty fungus and fly speck. *In* The More Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple. U. S. Dept. Agr. Farmers' Bul. 492, p. 36-37, fig. 21.

Give description. Disease is common in eastern states. Regular spray schedule, appended, will control.

Stevens, F. L.

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Gives morphology of the fungi. Notes meager knowledge of life histories.

Stevens, F. L., and Hall, J. G.

1913. Sooty Blotch. *Phyllachora pomigena* (Schw.) Sacc. Fly Speck. *Leptothyrium pomi* (Mont. et Fr.) Sacc.) *In* Diseases of Economic Plants, p. 94-95, fig. 38. New York City.

Give description of fungus, with control measures.

Sears, F. C.

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Theisen, S. J., and Sydow, H.

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Authors list *P. pomigena* under doubtful species.

Wilkinson, A. E.

1915. Sooty blotch and fly-speck fungus. *Leptothyrium pomi* (Mont. & Fr.) Sacc.) *In* The Apple, p. 226-227, fig. 102. Boston, Mass.

Brief general notes as to appearance and salability of affected fruit are given, with list of most susceptible varieties. Spray treatment recommended.

Blair, J. C., et al.

1916. Field Experiments in Spraying Apple Orchards. Ill. Agr. Exp. Sta. Bul. 185, p. 191, 202, 204-5.

The relative merits of Bordeaux mixture and lime sulfur in sooty blotch control discussed. Reported slight control with arsenate of lead used alone. Spray schedule recommended.

Higgins, B. B.

1916. Nomenclature of the fungus. *In* Plum wilt. Its nature and cause. Ga. Agr. Exp. Sta. Bul. 118, p. 13, 14.

Discusses his reasons for the name he gives plum wilt.

Salmon, E. S., and Wormald, H.

1916. Sooty Blotch of the Pear. *In* Gard. Chron., *59;* p. 58-59, fig. The "disease" reported as present on Catillac pears.

Description of symptoms. Claimed to be second to Thuemen (1879) in recording "disease" on pears.

Stevens, F. L.

1916. A convenient, little-known method of making micromounts of fungi. Phytopath., 6, p. 367.

Describes the use of celloiden for this purpose.

Winn, C. G.

1916. The Apple Crop of 1915. Trans. Ill. Hort. Soc. N. S. Vol. 49, p. 351, 352.

Reports serious infection of sooty blotch in unsprayed orchard, while trees nearby, sprayed three times with lime sulfur, were clean. "Clouded" fruit sold in Chicago for much less than clean fruit.

Whetzel, H. H., and Hesler, L. R.

1916. Sooty Blotch. *In* The Fruit Industry of New York State. N. Y. Dept. of Agr. Bul. 79, *I*, p. 869-870, fig. 244-245.

Describe fungus. Fly Speck is said to be another form. The late spray for scab should control.

Hesler, L. R., and Whetzel, H. H.

1917. Sooty Blotch and Fly-Speck. *Leptothyrium pomi* (Mont. & Fr.) Sacc. *In* Manual of Fruit Diseases. p. 104-108, fig. 28-29. New York.

Fungus described. Susceptible varieties of apples and pears listed. Geographical range noted. Provisional life history sketched. Control measures recommended.

Howitt, J. E., and Caesar, L.

1917. Sooty Blotch and Fly Speck. *In* The More Important Fruit Tree Diseases of Ontario. Ont. Agr. Col. and Exp. Farms Bul. 257, p. 12, illus.

Apples not injured as fungus is superficial. Affected fruit rendered unattractive, reducing sales. Control measures recommended.

Coons, G. H., and Nelson, Ray.

1918. Sooty Blotch. Fly Speck. (*Leptothyrium pomi*). *In* The Plant Diseases of Importance in the Transportation of Fruits and Vegetables. Am. Ry. Perishable Freight Assoc. Circ. 473-A, p. 16, fig. 19.

The presence of apples showing such superficial blemishes "in shipment is indicative of low-grade fruit, not properly sprayed."

Martin, G. W.

1918. Brown Blotch of the Kieffer Pear. In Phytopath. 8: 5, p. 234-8, fig. 9.

Description and experimental data. Probably closely related to *Leptothyrium pomi* but distinguished by its smaller size, straighter connecting strands, and that it burrows into the cutin and causes hypertrophy of the subcuticular layers. Spray schedule recommended.

Pickett, B. S., et al.

1918. Spraying Apple Orchards in 1913 and 1914. Ill. Agr. Exp. Sta. Bul. 206, p. 493.

Both Bordeaux mixture and lime-sulfur, used separately, completely controlled sooty blotch in both seasons. As high as 25% infection found in check plots.

Kempton, F. E.

1919. The Origin and Development of the Pycnidium. Thesis for degree of Ph. D. U. of Illinois, 1918. (Accepted for publication by the Bot. Gaz.)

A general discussion of pycnidial development with many illustrated examples.

## EXPLANATION OF PLATES

All plates are from photo-micrographs. The magnification used in Plates 1-4 is indicated in connection with the figures. The drawings for Plate 5 were made with the aid of a Bausch and Lomb drawing apparatus and a Leitz number six objective, giving a magnification of approximately 1,100 diameters, and are reduced two-thirds.

### PLATE I

Figure 7. Sooty blotch thalli of Fern-like type, x 160.
Figure 8. Branching mycelium of one of the above thalli, x 300.

### PLATE II

Figure 9. Immature pycnidia and mycelium, x 230.
Figure 10. Mature pycnidia and mycelium, x 230.
Figure 11. Sooty blotch thalli of the honey comb type, x 150.
Figure 12. Sooty blotch thalli of the reticulate type, x 230.

### PLATE III

Figure 13. Cross section of sooty blotch pycnidium on apple, x 200.
Figure 14. Cross section of sooty blotch mycelium on pear, x 160.
Figure 15. Cross section of sooty blotch mycelium on apple, x 160.
Figure 16. Cross section of fly speck on watermelon, x 160.
Figure 17. Cross section of fly speck on apple, x 200.

### PLATE IV

Figure 18. Antagonism of sooty blotch and fly speck on apple, x 2.
Figure 19. Sooty blotch and fly speck on blackberry, x 2.
Figure 20. Sooty blotch and fly speck on black mustard, x 2.
Figure 21. Sooty blotch pycnidium forced open, x 200.
Figure 22. Sooty blotch pycnidium with jagged aperture, x 230.
Figure 23. Spores and paraphyses of sooty blotch, x 230.

### PLATE V

Figure 24. Well developed thallus of sooty blotch.
Figure 25. Younger stage of sooty blotch thallus.
Figure 26. Still younger stage of sooty blotch thallus.
Figure 27. A beginning stage in pycnidial formation; on apple bark.
Figure 28. Later stage in pycnidial formation; on apple skin.
Figure 29. Later stage in pycnidial formation.
Figure 30. Nearly mature pycnidium.
Figure 31. Conidia of sooty blotch.
Figure 32. Paraphyses of sooty blotch.
Figure 33. Cross section of sooty blotch mycelium.
Figure 34. Diagram of cross section of sooty blotch pycnidium.

# THE GENUS SEPTORIA, PRESENTED IN TABULATION WITH DISCUSSION

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## INTRODUCTION

Much difficulty is often encountered in determining parasitic fungi. Large genera which parasitize a large number of host plants are particularly troublesome and often cause those not acquainted with the genus to give up in dispair. Septoria is one of the most troublesome of the larger genera and plainly in need of systematic and morphological study. Such a study will require years of work, but a simple method of listing species according to minimum spore length has been found of great help and is a convenient basis for studies in morphology besides affording means for rapid determination. In the following pages the Septoria species described in Saccardo's Sylloge Fungorum, Vols. 1-22 are listed in tabular form including the more important morphological characters together with a list of host plants and localities from which the species are reported. The family of each genus of hosts has been given a number and added to the list.

## CHARACTERS OF THE GENUS

The characters of the genus Septoria given by Saccardo, Lindau and others are essentially as follows: Pycnidium, subcuticular, globose-lenticular with a protruding ostiole; maculicole. Spores rod-shaped to filiform, many septate or many guttulate or continuous, hyalin. Basidia none or small. In the main features this description does not differ from that of Rhabdospora, the nearest ally, which is reported as not forming spots or of growing parasitically upon the stems of plants instead of leaves. The property of forming spots or of growing parasitically upon the stems of plants is not a really valid character for the separation of genera. Diedecke,[1] therefore, makes the further distinction that the

[1] Diedecke Die gatturg septoria. Ann. Myc. *10*, 478, 1912.

pycnidia of Rhabdospora possess thin-walled cells instead of thick-walled cells as in Septoria. Even this separation seems artificial and insufficient for the two genera. His definition of the genus Septoria, nevertheless, which appears to be more comprehensive and exact than those quoted above, follows: "Septoria umfasst alle diejenigen Arten, deren Fruchtlager sich durch Ausbildung einer Decke in ein pseudopyknidiales Gehäuse umwandelt, das oben mehr oder wenig breit geöffnet ist." Phleospora, regarded as the only other very close relative of Septoria is stated by Diedecke to be synonomous with Cylindrosporium.

## RELATION OF SPECIES TO HOST PLANTS

Popular methods of naming Septoria species consist of determinations of the generic characters and reliance upon the host index in ascertaining whether the species is new or old. The majority of the species of Septoria have been reported from flowering plants and when we consider that there are some 1,200 species of Septoria and less than 280 families of flowering plants, it will be seen that, if equally distributed, not less than four species must have been described from every family of flowering hosts in existence. Actual facts, however, show that from the more common families many more than this number have been described while from the less common families none at all are recorded. For instance: from the family Compositae, there are listed 113 species; from the Gramineae, 86; Leguminosae, 50; Rosaceae, 53; Umbelliferae, 52; Labiateae, 33; Caryophyllaceae, 34; Cruciferae, 22 and Solonaceae, 19.[2] Thus from nine families of flowering plants there are listed 38% of the described species of Septoria.

It has been found from a comparative study of the species that many reported from different genera of the same family of hosts have the same spore length and agree in all other described morphological particulars. From this it would seem as though the generic host limit

[2] Species without spore measurements are not included in this summary.

were too small. This fact, cannot, however, be accepte without thorough cultural studies of the genus.

## SPORE MEASUREMENTS

Attention is called to "inaccuracies" in the measure ment of spores best seen by a comparison of the numbe of species having a given minimum length. Thus th number of species having minimum lengths of 10, 2 30, 40, 50, and 60 mu. is much greater than the numbe with lengths of 15, 25, 35, 45, 55, etc., and these in tur are more numerous than those with minimum length of 14, 24, 34, 44, etc. This is also true if we conside maximum measurements and suggests that the absolut accuracy of these measurements is of questionable value It would thus appear to be more important to state th length in an even number of microns, say 20 to 30, or 2 to 35 than to use figures such as 19 to 28, or 24 to 3 simply because these measurements happen to give th range of the particular specimens examined.

## IMPORTANT SPECIFIC CHARACTERS

Of the various specific characters commonly mentione in descriptions none seem more important than spor length which, in Septoria, is to some extent correlate with diameter and septation. As regards spore color, a spores should be colorless, yet if we examine the table we find a number of species possessing spores with mor than permissable color. It is probable that these specie belong elsewhere. Ostiole measurements are thought t be of value and deserve more attention than has formerl been given them. The host is, under the present syste of determination, the factor most used in identificatio and its use affords the only convenient means of tracin a species. It is to be regretted that more reliable mean are not at hand but until complete cultural studies ar made this means of tracing species will continue to b important.

## EXPLANATION OF TABLES

The following explanation of the tables is necessary Figures in column 1 represent the number of the fungu

described in the Sylloge; the first number being that of the volume, the second that of the species in that volume. For instance, 3-110 refers to Septoria species 110 in volume 3 of the Sylloge. The second column presents the diameter of the pycnidia in microns. The third column gives the spore length, also in microns. This column is the key to the whole table, the "species" having been arranged first according to the minimum measurement, secondly according to the maximum. The fourth column gives the spore diameter in microns. In 5 and 6 the septa and guttulae, if present, are checked, if absent from the description the fact is indicated by a dash. If a definite number is present, figures giving the number of septa or guttulae are entered in the column. The sign ∞ means that the spores are multiseptate or guttulate. Continuous or entire spores are so indicated when the character is present in the description. Columns 7 and 8 representing curvature of the spore need no comment. The number in column 9 representing spore color correspond to the numbers given by Saccardo to different colors in his "Chromataxia." "A" here denotes hyalin spores. The significance of the remaining figures in this column may be determined by use of the following table:

A—Achrous ........................hyalin
2—Griseous..........gray (smoky, cloudy.)
4—Ater......................dark, blackish
22—Luteus..........egg-yellow, golden-yellow
23—Flavus ..........................yellow
30—Melleus......stone-colored, amber-colored
35—Viridis ...........................green
39—Olivaceous....................olive green

Column 10 represents spore shape, the numbers corresponding to those found in the following list:

1—Linear, filiform, vermiform, flagelliform or acicular.
3—Oblong, cylindrical, bacillar, rod-shaped, allantoid or terete.
4—Fusoid or fusiform.
6—Clavate.
7—Irregular.
9—∞

Column 11 is merely a list of the genera of hosts. Column 12 represents the families of hosts. The figures

corresponding to those given to the families of Siphon
gams by Dalla Torre and Harms.[3] The entire list is
be found in subsequent pages. Column 13 includes th
localities. The countries have been omitted from th
descriptions, in many cases there being only the name
some local town. An attempt has been made to suppl
the countries or nations as far as possible. Some
the species that have been quoted from a large numbe
of countries in Europe have been entered in this colum
simply from Europe.

## CONSIDERATION OF VARIOUS GROUPS OF SPECIES

The largest number of species from a single fam
ily is reported from the Compositae, but that is b
cause that family is broader in its limits than mos
of the others. Somewhat recently authors have, in fac
divided the original Compositae into a number of se
arate families. Of the 118 species from this family, 5
are described from Italy and Central Europe, i. e. Ge
many, France, Portugal, Austria, etc. It will be notice
that in many cases species from a given country ten
to group themselves together under similar spore length
In these groups other characters also correspond. Fo
instance, if we trace in the tables the species from Com
positae (280), beginning with spores 20-27 mu. in lengt
four species in succession occur from the United State
A fifth species from Silphium properly belongs in th
group. Again, beginning with species having a spor
length of 25 mu. we find three species from Italy, a
with spore lengths between the limits of 25-30 mu.

Among the species on Gramineae, we find the sam
grouping by countries. It is a notable fact that man
of the species here listed from the Gramineae are ge
eral parasites and are capable of affecting most grasse
Twenty-six of the species are included between the mini
mum spore lengths of 20-24 mu. while many others la
over into these limits. Septation is slightly more com
mon than in the Septorias on Compositae, and ther

[3] C. G. Dalla Torre et H. Harms, Genera Siphonogamarum.

seems to be a predominance of rod-shaped spores over other shapes.

Twenty-three of the fifty species from Leguminosae are rod-shaped, fourteen are filiform. It will also be noted that a large part of them are septate. The variation in spore length is great, and ranges from 10 to 120 mu.

Most of the species in the "Umbelliferae" group may be included within the limits of spore length of 25-50 mu, and it is probable that many of these are synonious with *S. petroselinum*, var. *apii*, the common form on celery.

There is nothing of special importance connected with the species on Labiatae except that there is a general absence of septation.

Of the group from the Rosaceae, thirteen species have been described from Prunus alone. This amounts to 25% of the species from this family.

Species from the Caryophyllaceae present some interesting features. First, nearly all spores seem to be rod-shaped; second, there are few continuous spores.

In the group from Cruciferae, one group on Sysimbrium from Servia with a spore length of 19-62 mu. may be considered as including 16 of the 22 species from this family.

Nearly one-half of the species from the family Solonaceae are reported from Solanum.

Approaching the tables from the standpoint of morphology alone, there will be noted a general similarity between species with given spore lengths, as regards septation, spore shape, locality, etc. Thus on page 1 of the general tables, we see six species with spore lengths of 10-12 mu. all reported from Italy with the exception of one from France. The diameters of the spores are very similar and the septation is definite. All have rod-shaped spores and in all cases where the fact is mentioned the spores are curved. The largest groups of this kind are those with spore measurements lying between 20 and 25 mu. and 20 and 30 mu. Each of these contain over thirty species and probably include many identical forms.

The spores of nearly 700 species fall within the limits of 20 and 50 mu, and when we remember that few other characters are of constant diagnostic value it appears possible that with proper cultural studies a large number of Septoria species may be united. In Saccardo's Sylloge V. 22 a species is described (no. 4) having a spore length ranging from 19-62 mu. If this be a single species, which is entirely possible, then there appears to be no reason why the 700 species mentioned could not with proper methods of study be proven to belong to a small number of specific types. Such a wholesale elimination of species would probably not be acceptable to workers in this field, but it seems to be fully as warranted in the light of our knowledge to-day as the erection of myriads of species based largely on the host plant which they parasitize. It is to be hoped, however, that this tabulation will form a stepping stone to a more complete knowledge of the genus such as is obtained only by cultural and biological studies and that it will serve to attract the general student of pathology to this large and interesting genus, about which we know so little.

SPECIES OF SEPTORIA IN ORDER OF LENGTH OF SPORE

| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3–111 | ....... | 5 | ........ | — | — | ..... | .... | A | 1–3 | Andromeda ........ | 233 | U. S. A. (Ala.) |
| 10– 66 | ....... | 5 | 1 | — | ∞ | * | * | A | 1 | Unknown .......... | ... | N. Zealand. |
| 3–186 | ....... | 5–7 | 1.5–2.5 | 1 | — | * | .... | A | 3 | Podocarpus ........ | ... | S. Africa, Cape of G. Hope. |
| 3–114 | ....... | 6–10 | ........ | — | — | * | .... | A | 4 | Jasminum ......... | 243 | France. |
| 11– 72 | 30 | 6–12 | 1–1.2 | C. | — | ..... | .... | .... | ... | Asprella .......... | 19 | U. S. A. (Ind.). |
| 3–122 | ....... | 7–8 | 1.5 | — | * | * | * | A | 3 | Olea .............. | 243 | Abyssinia. |
| 3–254 | ....... | 7–9 | 3.5–4.5 | — | — | ..... | .... | .... | 9 | Stellaria .......... | 87 | Germany. |
| 3–131 | ....... | 7–10 | 2–2.5 | 1–2 | — | * | .... | A | 3 | Paulownia ........ | 257 | Italy and France. |
| 3–565 | ....... | 7–11 | 1.5 | C. | | ..... | .... | A | 3–4 | Tamnus ........... | 43 | France. |
| 16– 25 | 70–80 | 7–12 | 1.5–2 | C. | | ..... | * | A | 3 | Acer .............. | 163 | N. America. |
| 10– 61 | 80–150 | 7–18 | 1–2 | — | * | ..... | * | A | 1 | Salix .............. | 56 | N. America. |
| 3–125 | ....... | 8 | ........ | — | — | ..... | .... | A | 1 | Chionanthus ....... | 243 | U. S. A. (S. Car.). |
| 3–268 | ....... | 8–11 | 2 | 1 | — | ..... | * | 2 | 3 | Matthiola ......... | 105 | Portugal. |
| 3–230 | ....... | 8–12 | 1.5 | C. | ∞ | * | .... | A | | Impatiens ......... | 168 | Russia. |
| 3–478 | ....... | 8–12 | 2.5–3 | 1? | — | ..... | * | A | 3 | Juglans ........... | 60 | Italy. |
| 3–570 | ....... | 8–14 | 3 | 3–5 | 5 | * | * | A | 3 | Iris ............... | 44 | Portgual. |
| 3– 14 | 80–90 | 8–15 | 1.5–2 | — | — | * | .... | A | | Citrus ............ | 137 | Italy. |
| 10–189 | 150–200 | 8–16 | 1.5–2 | C. | | ..... | * | A | 1–6 | Cocos ............. | 21 | U. S. A. (Mo.) |
| 14– 54 | ... ... | 8–30 | 1.5–2 | C. | * | * | * | .... | 3 | Armeria ........... | 238 | Greenland. |
| 10–218 | 84–96 | 9–11 | .5–.75 | C. | | ..... | * | A | 3 | Triticum .......... | 19 | Italy. |
| 3– 15 | ....... | 9–12 | 2–3 | 1 | — | * | * | A | 3 | Citrus ............. | 137 | Canary Islands. |
| 3–180 | ....... | 9–14 | ........ | — | — | ..... | .... | A | 3 | Betula ............ | 61 | America. |
| 10–141 | 80–90 | 9–23 | 3–3.5 | 1–3 | — | * | .... | A | 3 | Ambrosia .......... | 280 | Italy. |
| 3–535 | 80 | 10 | 3.5 | *? | — | ..... | .... | .... | 4 | Rhynchospora ..... | 20 | England and Belgium. |
| 3–555 | ....... | 10 | 2.5–3 | 1 | * | ..... | .... | A | 3 | Yucca ............. | 38 | ................ |
| 3–164 | ....... | 10 | ........ | — | — | ..... | * | A | 4 | Corylus ........... | 61 | England and Italy. |
| 3–146 | ....... | 10 | ........ | — | — | ..... | .... | .... | 1 | Artocarpus ........ | 64 | India. |
| 10–153 | 70–90 | 10 | 1.5–2 | C. | | — | * | A | 1 | Lamium ........... | 254 | Italy. |
| 3–487 | ....... | 10–12 | .7 | C. | — | * | * | A | ... | Agropyron ........ | 19 | Italy. |
| 18– 6 | 50–65 | 10–12 | 1.5 | — | — | * | * | A | 3 | Genista ........... | 128 | Italy. |
| 10– 53 | ....... | 10–12 | 2 | *? | — | ..... | * | .... | 3 | Prasium ........... | 251 | Italy. |
| 16– 14 | ....... | 10–12 | 2 | — | ∞ | ..... | .... | A | 3 | Vitis .............. | 170 | Italy. |
| 16– 7 | ....... | 10–12 | 2 | *? | ∞ | * | * | .... | 3 | Kadsura ........... | 45 | Italy. |
| 10– 59 | ....... | 10–12 | 2–2.5 | C. | | ..... | .... | A | 3 | Populus ........... | 56 | France. |

| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10–136 | 70–100 | 10–13 | 1.5 | — | — | * | * | .... | 6 | Solidago .......... | 280 | N. America. |
| 3– 69 | ....... | 10–14 | 3 | 1-2 | — | ..... | * | A | 3 | Cydonia .......... | 126 | Italy. |
| 3– 13 var. | ....... | 10–14 | 2.5–3 | 1 | — | * | .... | A | 4 | Citrus .......... | 137 | Italy. |
| 3– 16 | 100–120 | 10–11 | 3–3.1 | 0 | [illegible] | * | .... | A | 4 | Citrus .......... | 137 | Italy. |
| 14– 27 | ....... | 10–11 | 4–6 | 1 | 8 | * | * | A | 3 | **Aphania** .......... | **165** | **Africa** (Erythrea). |
| 10– 74 | ....... | 10–14 | 3 | 1 | — | * | .... | .... | 3 | Arabis .......... | 105 | Greenland. |
| 16– 51 | 80–100 | 10–14 | 2–3 | 1–3 | — | ..... | .... | A | 3 | Chaerophyllum .... | 228 | Germany (Saxony). |
| 3–113 | ....... | 10–15 | 1.2–2 | 1 | 2 | * | * | A | 3–6 | Bumelia .......... | 239 | Italy. |
| 3–476 | ....... | 10–15 | 1.5 | 2–3 | * | * | * | .... | ... | Olea .......... | 243 | Austria. |
| 3–472 | 60–70 | 10–15 | 1.5 | — | * | ..... | * | A | 3 | Catalpa .......... | 258 | Italy. |
| 10– 55 | ....... | 10–15 | 1.3 | C. | — | * | * | A | 3 | Arbutus .......... | 233 | Italy. |
| 3–295 | 50–70 | 10 16 | 1.5 | 1 | — | ..... | * | A | 3 | Delphinum .......... | 91 | Portgual. |
| 11– 3 | 55–85 | 10–16 | 1 | C. | | * | * | A | ... | Lunaria .......... | 105 | Canada. |
| 22– 32 | 70–100 | 10–16 | 2–3 | — | 1–2 | ..... | * | A | 3 | Prunus .......... | 126 | Silesia. |
| 3– 38 | ....... | 10–20 | 2.5 | — | — | * | * | .... | 3 | Rhamnus .......... | 169 | Italy. |
| 3– 35 | ....... | 10–20 | 1.5 | — | — | ..... | * | A | 1 | Rhamnus .......... | 169 | Holland. |
| 16– 33 | ....... | 10–20 | 3–4 | 1–3 | — | ..... | * | A | ... | Silene .......... | 87 | Palestine. |
| 14– 30 | ....... | 10–20 | 2 | 1–C. | | * | .... | A | 3 | Saxifraga .......... | 117 | Greenland. |
| 16– 66 | ....... | 10–20 | 2 | *? | — | * | .... | A | 3 | Maesa .......... | 236 | Italy. |
| 14– 18 | ....... | 10–20 | 1.5–2.5 | C.–1 | | * | * | A | 1 | Vitis .......... | 170 | Tunis. |
| 14– 19 | ....... | 10–20 | 1.5–2.5 | C. | | * | .... | A | 3 | Sorbus .......... | 126 | Germany. |
| 10–148 | ....... | 10–25 | 1.5–2 | — | * | ..... | .... | A | ... | Citrullus .......... | 275 | U. S. A. (N. J.). |
| 22–156 | 90–180 | 10–35 | 3–4 | 1–3 | — | * | * | A | 3–6 | Pteris .......... | | Italy. |
| 10–206 | ....... | 11–13 | 3 | C. or — | | * | * | .... | ... | Carex .......... | 20 | Fennia. |
| 10–197 | 70–80 | 11–14 | 1.5 | — | — | ..... | * | A | 3 | Aspidistra .......... | 38 | Italy (Rome). |
| 16– 16 | 120–200 | 11–15 | 3–3.5 | 1 | * | * | * | A | 3 | Citrus .......... | 137 | Australia (Melbourne). |
| 22–151 | 70–130 | 11–18 | 2–2.5 | — | — | * | * | A | 4 | Oryzopsis .......... | 19 | Turkey in Asia (Anatolia). |
| 22–120 | 40–90 | 11–20 | 2 | 1 | — | * | * | A | 4 | Mercurialis .......... | 147 | Montenegro. |
| 3–503 | ....... | 12 | 2.3 | 1 | — | ..... | .... | A | ... | Poa .......... | 19 | Holland. |
| 3–480 | ....... | 12 | ........ | — | — | ..... | * | .... | ... | Cucurbita .......... | 275 | U. S. A. (Pa.) |
| 3–101 | | 12 | 4 | 2 | — | * | .... | A | 3 | Lonicera .......... | 271 | Portgual. |
| 3– 10 | ....... | 12 | 4 | 1 | 4 | * | * | A | 3 | Brachychiton .......... | ... | Portugal. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3–77 | ....... | 12 | 2.5 | — | — | ..... | .... | A | 2 | Prunus ........... | 126 | Italy. |
| 3–41 | ....... | 12–13 | 2.5 | C. | | * | .... | A | 3 | Evonymus ........ | 158 | Italy. |
| 16–27 | ....... | 12–14 | 1.5–2 | ∾ | — | * | * | A | 3 | Hermannia ........ | 178 | Italy. |
| 14–24 | 100–120 | 12–14 | 1.5–2 | C. | ∞ | * | * | A | 3 | Banisteria ........ | 14 | Italy. |
| 16–83 | 90–100 | 12–14 | 3 | 1 | — | ..... | .... | A | 1 | Osmanthas ........ | 243 | Italy. |
| 10–40 | 150–180 | 12–14 | 1–1.5 | C. | | * | .... | A | 3 | Maytenus ......... | 158 | Fuegia. |
| 18–61 | ....... | 12–15 | 3–4 | — | 4 | * | .... | A | 3 | Primula .......... | 237 | Denmark. |
| 16–96 | 80–120 | 12–15 | 1.5 | C. | | — | * | A | ... | Calamagrostis ..... | 19 | U. S. A. (Wisc.). |
| 16–6 | | 12–15 | 2–2.5 | *? | ∞ | * | * | A | 3 | Lardizabala ....... | 92 | Germany. |
| 3–87 | ....... | 12–15 | 1 | 1 | — | ..... | .... | A | ... | Deutzia ........... | 117 | France. |
| 3–43 | 100 | 12–15 | 1.5–2 | 1 | — | * | * | A | 3–4 | Paliurus .......... | 169 | Italy. |
| 3–53 | ....... | 12–15 | 2–2.5 | — | ∾ | * | .... | A | ... | Ceratonia ......... | 128 | Italy. |
| 3–144 | 80 | 12–15 | 1 | — | — | ..... | .... | A | 1 | Ficus ............. | 65 | France. |
| 3–127 | ....... | 12–15 | 2–2.5 | C.–1 | — | ..... | * | A | 3 | Ligustrum ........ | 243 | Italy. |
| 3–154 | 100 | 12–15 | 1–1.5 | 0–1 | — | ..... | .... | A | 3–4 | Pircunia .......... | 83 | Argentina. |
| 16–40 | 80 | 12–16 | 1 | C. | | ..... | * | A | 4 | Valeriana ......... | 273 | France. |
| 10–57 | ....... | 12–16 | 1.2–1.5 | — | — | ..... | * | .... | ... | Carya ............ | 60 | U. S. A. (Del.). |
| 3–8 | ....... | 12–16 | 2–2.5 | C. | — | ..... | * | A | 1–3 | Hibiscus .......... | 175 | Austria (Gorizia). |
| 3–94 | ....... | 12–16 | 1 | — | 6–7 | ..... | * | A | 1 | Ribes ............. | 47 | Italy, Belgium, Austria. |
| 3–517 | 40–60 | 12–16 | 1.5–2 | — | * | * | * | A | 3–4 | Carex ............ | 20 | Lapland. |
| 14–20 | ....... | 12–16 | 2 | 1 | — | * | * | A | 4 | Prunus ........... | 126 | France. |
| 22–150 | 90 | 12–17 | 2–2.5 | — | 1 | ..... | * | A | 4 | Phleum ........... | 19 | Denmark. |
| 18–79 | 50–80 | 12–18 | 2 | 1 | — | * | * | A | 1 | Ophiopogon ....... | 39 | Sicily. |
| 14–49 | ....... | 12–18 | 1.5–2.5 | 1–3 | — | ..... | * | A | 3 | Azalea ........... | 233 | Northern Italy. |
| 3–223 | 90–100 | 12–18 | 1–1.5 | 3? | — | * | * | A | 3 | Jussiaea .......... | 224 | Argentina. |
| 3–73 | ....... | 12–18 | 3.5–4 | C. | | ..... | * | A | 4 | Pyrus ............ | 126 | Austria. |
| 3–199 | ....... | 12–18 | 4.5–5 | 1 | 2–4 | ..... | ..... | A | 3 | Soja ............. | 128 | Italy. |
| 10–199 | 90–100 | 12–18 | .5–1 | ∞? | — | ..... | .... | A | 1 | Bidens ........... | 280 | Brazil. |
| 3–29 | ....... | 12–18 | 1.5 | C. | | ..... | * | A | 1 | Vitis ............. | 170 | Italy. |
| 3–59 | ....... | 12–20 | 2 | C. | | * | * | A | 3 | Cytisus .......... | 128 | Italy. |
| 11–6 | 75 | 12–20 | 1–1.2 | — | * | ..... | .... | .... | ... | Lespedeza ........ | 120 | Canada. |
| 16–9 | 60–80 | 12–20 | .5–1 | * | — | ..... | * | A | 1 | Guatteria ......... | 98 | Brazil (Sao Francisco). |
| 16–75 | 100–120 | 12–20 | 1–1.25 | C. | * | ..... | * | .... | ... | Plumeria ......... | 247 | Central Am. |
| 18–21 | 40–80 | 12–20 | 1.7–2.5 | 1 or C. | | * | * | A | 3 | Viscaria .......... | 87 | Bohemia. |
| 22–103 | 80–120 | 12–30 | 1 | 1–3 | — | ..... | * | .... | 1 | Tozzia ............ | 257 | Austria (Tirolia). |
| 10–212 | ....... | 13–15 | 2–3 | C. | * | ..... | * | .... | 4 | Calamagrostis ..... | 19 | Greenland. |
| 18–66 | 45–55 | 13–15 | 1.3 | C. | * | ..... | * | A | 3 | Asclepias ......... | 218 | Portugal. |
| 10–191 | 100–130 | 13–16 | 1 | C.–4–5 | | * | * | A | 3 | Tritoma .......... | 38 | Ecuador. |
| 16–84 | 180–200 | 13–18 | 2–3 | C. | | * | .... | A | 3 | Salix ............. | 56 | Norway. |
| 16–15 | 112 | 13–19 | 1.5–3.5 | 1 | — | ..... | .... | A | 3 | Citrus ............ | 137 | Australia (Melbourne). |
| 18–5 | 60 | 13–20 | 1 | — | — | * | * | .... | 1 | Oxytropis ......... | 128 | Germany (Thuringia). |

| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-471 | ....... | 14 | 1.75 | 1-C. | | ..... | * | A | 3-4 | Asarum ........... | 74 | Italy. |
| 16- 30 | 50-60 | 14-15 | 2.5 | C. | | * | .... | A | 3 | Astilbe ........... | 117 | Italy. |
| 16- 49 | ....... | 14-16 | 2 | 1-C. | | * | * | A | 3 | Bupleurum ........ | 228 | Italy. |
| 16- 37 | 70-80 | 14-16 | 2 | — | * | * | * | A | 3 | Cliffortia ......... | 126 | Italy. |
| 16- 43 | 150-160 | 14-16 | 1 | C. | — | ..... | * | A | 1-4 | Pascalia .......... | 280 | Argentina. |
| 18- 82 | 105 | 14-16 | 1.2 | C.-2-5 | | ..... | * | A | ... | Thelymitra ....... | 50 | Australia (Victoria). |
| 22- 11 | 80-120 | 14-17 | 1.5 | 1? | — | * | * | .... | 3 | Zizyphus .......... | 169 | Portugal. |
| 3- 13 | ....... | 14-18 | 2-3 | 0-1 | — | * | .... | A | 3 | Citrus ............ | 137 | Europe. |
| 3-120 | 100-120 | 14-18 | 1.5-2.5 | 0-1 | — | ..... | * | A | 3 | Syringa .......... | 243 | Italy, France. |
| 16- 36 | ....... | 14-18 | .3-.6 | * | 2 | * | * | A | 1 | Chorizema ....... | 128 | Germany. |
| 3-346 | ....... | 14-20 | 1 | — | * | ..... | * | | 3 | Pentstemon ....... | 257 | U. S. A. (Ill.). |
| 10-214 | ....... | 14-20 | 3.5-4.5 | C. | | ..... | * | A | 4 | Phragmites ....... | 19 | Fennia. |
| 22-155 | 80-120 | 14-20 | .7-1 | C. | | * | * | A | ... | Triticum .......... | 19 | Hungary. |
| 22- 46 | 80-100 | 14-20 | 1.5-2 | — | — | * | * | .... | ... | Kennedya ......... | 128 | ............... |
| 22- 33 | 120-150 | 14-22 | 1.5-2 | 1-3 | * | * | * | A | 3 | Eriobotrya ........ | 126 | Italy. |
| 18- 42 | ....... | 14-28 | 1 | 1-C. | | ..... | * | A | ... | Homogyne ........ | 280 | Austria (Tirolia). |
| 3- 5 | ....... | 15 | 5 | 2-3 | 3 | * | * | A | 3 | Corynocarpus ...... | 156 | Portugal. |
| 3- 44 | ....... | 15 | 1 | — | — | ..... | * | A | 1 | Zizyphus .......... | 169 | Italy. |
| 3-106 | ....... | 15 | ....... | — | — | * | * | A | 1 | Vaccinium ........ | 233 | America. |
| 3-111 | ....... | 15 | ....... | — | — | ..... | .... | A | 1 | Symplocos ........ | 24 | America. |
| 3-115 | ....... | 15 | 2 | — | — | * | .... | A | 3 | Jasminus ......... | 243 | Italy. |
| 3-123 | ....... | 15 | 2.5 | — | 8 | ..... | .... | A | 3 | Phillyrea ......... | 213 | Algeria. |
| 3-408 | ....... | 15 | 4 | 1 | 2 | * | .... | A | 4 | Solidago .......... | 280 | U. S. A. (Car.). |
| 3-542 | ....... | 15 | ....... | — | * | * | .... | A | 3 | Alisma ........... | 15 | Italy. |
| 3-557 | ....... | 15 | 1.5 | — | — | * | * | A | 3 | Aloe ............. | 40 | Belgium. |
| 11- 54 | ....... | 15 | 2.5 | — | — | ..... | .... | .... | ... | Kalmia ...... .... | 133 | ............... |
| 14- 46 | ....... | 15 | 3 | — | 4 | ..... | .... | A | 1-3 | Teucrium ......... | 254 | France. |
| 16- 24 | ....... | 15 | 4-5 | C. | * | * | .... | A | 4 | Evonymus ......... | 158 | Holland. |
| 3-171 | ....... | 15-16 | 1.5 | 1 | — | * | * | A | ... | Quercus .......... | 62 | Portugal. |
| 3- 37 varB | ....... | 15-16 | 1.7-2 | — | — | ..... | * | A | ... | Rhamnus .......... | 169 | France. |
| 10- 14 | 130-140 | 15-16 | 2 | 1 | — | ..... | .... | A | 4 | Acacia ........... | 128 | Australia. |
| 14- 56 | ....... | 15-16 | 2.5 | — | 4 | * | * | A | 3 | Garrya ........... | 229 | France. |
| 14- 71 | 80-100 | 15-16 | .7-1 | C. | | * | .... | A | 3 | Orchis ........... | 50 | Siberia. |
| | | | [illegible] | | * | * | [illegible] | A | 4 | Vitis ............. | 170 | France. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10–11 | 90–100 | 15–18 | 1.5 | — | 2 | ..... | .... | A | ... | Hardenbergia | 128 | Australia (Norwood). |
| 10–190 | 80 | 15–18 | 1 | — | — | ..... | * | A | 3 | Latania | 21 | Italy (Rome). |
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| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
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| 10–110 | 100–125 | 50–60 | 4 | — | — | ..... | * | A | 1 | Osmorrhiza ....... | 228 | U. S. A. (N. Y.). |
| 10–142 | 100–200 | 50–60 | 1–1.5 | 5–7 | — | ..... | * | 22 | 1 | Cephalaria ....... | 274 | France. |
| 11– 53 | ....... | 50–60 | 2 | — | — | * | * | .... | 1 | Limnea ........... | 15 | Norway. |
| 16– 5 | ....... | 50–60 | 2.5–3.5 | 3 | — | * | * | A | 3 | Capsella ......... | 105 | Holland. |
| 22– 92 | 90–100 | 50–60 | 4–5 | 1–3 | — | * | * | A | 4 | Mutisia .......... | 280 | Argentina. |
| 22–146 | 120–150 | 50–60 | 1 | C. | | ..... | * | A | 1 | Panicum .......... | 19 | Argentina. |
| 3–283 | ....... | 50–60 | 2.5 | 4–6 | * | ..... | .... | A | 4 | Ranunculus ....... | 91 | Belgium. |

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| 3-236 | 80-90 | 50-60 | 1-1.5 | 3 | 3 | ..... | .... | A | 1 | Bowlesia .......... | 228 Argentina. |
| 3-352 | ....... | 50-60 | 1.7 | 3-4 | — | * | * | .... | 1 | Solanum .......... | 256 Europe. |
| 3-246 | ....... | 50-60 | ........ | — | — | ..... | * | .... | 1 | Lepidium .......... | 105 Europe. |
| 3-206 | ....... | 50-60 | 3 | 3-5 | — | ..... | * | A | 3 | Lathyrus .......... | 128 Italy. |
| 3-147 | ....... | 50-60 | 1.5 | — | ∞ | ..... | * | A | 1 | Quercus .......... | 62 U. S. A. (S. Car.). |
| 3-142 | ....... | 50-60 | ........ | — | ∞ | ..... | .... | .... | 1 | Ficus .......... | 65 India. |
| 3- 26 | ....... | 50-60 | 3-3.5 | 3-4 | — | ..... | * | A | 3-4 | Aesculus .......... | 164 Austria. |
| 3- 63 | ....... | 50-60 | 2.5-3 | 4-5 | — | ..... | .... | A | 1 | Rosa .......... | 126 Italy. |
| 3-233 | ....... | 50-60 | 1 | *? | ∞ | ..... | * | A | 1 | Geranium .......... | 129 Austria (Moravia). |
| 3-385 | ....... | 50-60 | 2-2.5 | — | ∞ | ..... | * | A | 3 | Apocynum .......... | 247 Northern Italy. |
| 3-498 | ....... | 50-60 | 2 | — | ∞ | ..... | * | A | 1-6 | Bromus .......... | 19 Northern Italy. |
| 3-552 | ....... | 50-60 | ........ | — | — | ..... | * | .... | 1 | Allium .......... | 38 India. |
| 10-144 | 160-208 | 50-60 | 1.5-2 | C. | * | * | * | .... | 1 | Galium .......... | 270 U. S. A. (Kan.). |
| 22-111 | 150 | 50-65 | 1.5 | C. | *? | * | * | A | 1 | Azalea .......... | 233 Brazil (Sao Paulo). |
| 3-497 | ....... | 50-65 | 1.2-2 | — | — | ..... | .... | A | 1 | Cynodon .......... | 19 Rhenogovia, Italy. |
| 3-511 | ....... | 50-65 | 1.7-2 | 3 | ∞ | * | * | A | | Phragmites .......... | 19 Northern Italy. |
| 16- 97 | 80-100 | 50-65 | 2.5-3.5 | ∞ | — | * | * | A-23 | 3 | Alopecurus .......... | 19 Germany. |
| 16- 28 | 180-220 | 50-65 | 2 | C. | | ..... | * | A | 1 | Geranium .......... | 129 Italy. |
| 3-578 | ....... | 50-65 | 4 | — | * | | | A | 3-6 | Pteris .......... | ... Northern Italy. |
| 10-181 | 100-125 | 50-68 | 3 | — | * | ..... | * | A | 3 | Rumex .......... | 77 Siberia. |
| 3-563 | ....... | 50-70 | 3 | — | 6-9 | ..... | .... | .... | 3 | Maianthemum ..... | Belgium. |
| 3-547 | ....... | 50-70 | 2-3 | *? | — | ..... | .... | A | 1 | Ornithogallum ..... | 38 "Czernatal." |
| 22- 79 | 100-150 | 50-70 | 2-2.5 | 3-5 | — | ..... | * | A | 1-6 | Tanacetum .......... | 280 "Hercules-Furdo." |
| 22- 77 | 80-160 | 50-70 | 2 | * | — | ..... | .... | A | 1-6 | Chrysanthemum ... | 280 Poland (Galicia). |
| 16- 42 | ....... | 50-70 | 2-2.5 | C. | | ..... | * | .... | 1 | Asperula .......... | 270 Italy. |
| 10-125 | 87-105 | 50-70 | 1.5-2 | ∞ | — | ..... | .... | A | ... | Lepachys .......... | 280 U. S. A. (Mo.) |
| 11- 12 | 150-160 | 50-70 | 3-4 | 3-∞ | — | ..... | .... | 39 | ... | Sorbus .......... | 126 Germany (Saxony). |
| 18- 51 | 100 | 50-70 | 1.7-2 | — | * | * | .... | A | 3 | Linaria .......... | 259 Italy. |
| 22- 13 | 90-120x 110-150 | 50-70 | 2.2 | 3-4 | — | * | * | .... | 1 | Geranium .......... | 129 Montenegro. |
| 3-426 | ....... | 50-70 | 3-5 | *? | ∞ | ..... | * | A | 3 | Senecio .......... | 280 Northern Italy. |
| 3-251 | ....... | 50-70 | 2.5-3 | 5-7 | — | * | * | A | 1 | Lychnis .......... | 87 France. |
| 3-282 | ....... | 50-70 | 1.5 | — | ∞ | * | * | A | 1 | Ranunculus .......... | 91 Europe. |
| 3- 80 | ....... | 50-75 | ........ | — | — | ..... | * | .... | 1 | Prunus .......... | 126 North America. |
| 3-102 | ....... | 50-75 | ........ | 6 | — | ..... | * | A | 1 | Sambucus .......... | 271 U. S. A. (N. Y.). |
| 3-428 | ....... | 50-75 | ........ | — | — | ..... | * | .... | 1 | Aster .......... | 280 U. S. A. (N. Y.). |
| 3-479 | 140-150 | 50-75 | 1.7-2.5 | — | ∞ | ..... | .... | A | 1-3 | Abies .......... | 6 "Arduennis." |
| 20- 67 | 100-120 | 50-75 | 2.5-3 | — | ∞ | ..... | * | A | | Calycophyllum .... | 270 ................ |
| 14- 33 | ....... | 50-75 | 2-3 | 2-∞ | — | ..... | .... | A | 3 | Pyrethrum .......... | 280 Germany. |
| 3-519 | ....... | 50-75 | 2.7 | 5-6? | — | * | * | A | 1 | Scilla .......... | 38 Europe. |
| 10- 95 | ....... | 50-75 | 1.5-2.5 | — | ∞ | * | * | A | 1 | Sedum .......... | 115 "Fennia." |

| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10–101 | 40–50 | 50–75 | 1.5 | — | * | * | .... | A | 1 | Saxifraga ......... | 117 | U. S. A. (Wisc.). |
| 22– 67 | 100–120 | 50–75 | 2.5–3 | — | ∞ | ..... | * | A | 1 | Calycophyllum .... | 270 | Argentina. |
| 3–428 | ....... | 50–75 | ........ | — | — | ..... | * | .... | 1 | Leucanthemum .... | 280 | North America. |
| 16– 22 | 100–140 | 50–75 | 2.5–3 | 1–3 or C. | | * | * | 23 | 1 | Gaura ............. | 224 | U. S. A. (Kan.). |
| 10–109 | ....... | 50–80 | 2–3 | ∞ | ~ | ..... | * | A | 1 | Chaerophyllum .... | 228 | Germany (Bavaria). |
| 11– 28 | ....... | 50–80 | 2–3 | ∞ | * | ..... | .... | A | ... | Chaerophyllum .... | 228 | Germany (Bavaria). |
| 22–105 | 80–100 | 50–80 | 3–4 | 3–5 | — | ..... | * | A | 1 | Solanum .......... | 256 | Argentina (La-Plata). |
| 3–534 | 150–200 | 50–80 | 3 | — | 12–20 | ..... | * | –? | 1–3 | Juncus ........... | 36 | France. |
| 22–152 | 90–100 | 50–80 | 2.5–3 | 5–8 | ~ | ..... | * | A | ... | Oryza ............. | 19 | Japan. |
| 16– 13 | ....... | 50–84 | 1–2 | C. | 0 | * | .... | A | 1 | Ampelopsis ........ | 170 | Germany (Berlin). |
| 18– 28 | 100–250 | 50–85 | 2.5–3 | 1 | — | * | * | A | 3 | Chaerophyllum .... | 229 | Austria (Bohemia). |
| 22– 53 | 140–250 | 50–85 | 3–4.5 | 1 | 1 | * | * | A | ... | Pimpernella ....... | 228 | Austria (Tirolia). |
| 3–208 | ....... | 50–87 | ........ | — | * | * | * | .... | 1 | Lathyrus .......... | 128 | U. S. A. (N. Y.). |
| 3–297 | 120–130 | 50–100 | 2–4 | * | * | ..... | .... | A | 1–3 | Aconitum ......... | 91 | Northern Italy. |
| 22– 97 | 90–100 | 50–100 | 1.5–2 | C. | — | ..... | * | A | 1 | Ambrosia ......... | 280 | Argentina (La-Plata). |
| 18– 9 | 140–175 | 52–56 | 3.5–4 | 2–3 | — | ..... | * | A | ... | Mesembryanthemum | 82 | Australia (Victoria). |
| 16– 88 | 120–150 | 54–60 | 4–5 | ∞ | — | * | * | A | ... | Asphodeline ...... | 38 | Bulgaria. |
| 22–138 | 120–160 | 54–70 | 2.5–3 | C. | ~ | * | * | 23 | 3 | Schoenus .......... | 280 | Hungary. |
| 3–102 | ....... | 55 | 3 | ∞ | — | * | * | .... | 4 | Tussilago ......... | 280 | Northern Italy. |
| 3–189 | ....... | 55 | ........ | — | — | ..... | .... | .... | 1 | No host given..... | | U. S. A. (Ala.). |
| 3–453 | ....... | 55 | 2.5 | ∞ | — | * | * | A | 1 | Plantago .......... | | Italy. |
| 3–151 | ....... | 55–60 | ........ | — | — | ..... | * | A | 1 | Liquidambar ...... | 123 | U. S. A. (N. J.). |
| 3– 25 | ....... | 55–60 | 2.5 | C. | | ..... | * | A | 1 | Aesculus .......... | 165 | Italy. |
| 11– 36 | 100–120 | 55–65 | 1.5–2 | C. | | ..... | .... | A | 1 | Chrysanthemum ... | 280 | Northern Italy. |
| 3–436 | ....... | 55–60 | 1.5–2 | 2–4 | — | ..... | * | A | 3 | Centaurea ........ | 280 | France. |
| 22– 78 | 80–140 | 55–70 | 2.5–3.5 | ∞ (10–15) | — | * | * | A | 1 | Chrysanthemum ... | 280 | Austria (Bohemia). |
| 3–515 | ....... | 55–75 | 1–1.3 | C. or * | — | ..... | * | A | ... | Graminae ......... | 19 | Europe and America. |

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| 3-366 | ....... | 58 | 1-2 | C. | — | ..... | .... | A | ... | Mentha .......... | 254 | Austria (Bohemia). |
| 3-390 | ....... | 60 | 3 | 3 | — | ..... | .... | .... | 1 | Galium .......... | 270 | North America. |
| 3-538 | ....... | 60 | 2 | — | ∞ | ..... | .... | 23 | 1 | Typha .......... | 8 | France. |
| 3-576 | ....... | 60 | 3 | — | ∞ | ..... | * | A | 3 | Equisetum .......... | ... | France. |
| 3-544 | ....... | 60 | 4 | — | * | ..... | .... | A | 3-4 | Veratrum .......... | 38 | Siberia. |
| 3-265 | ....... | 60 | 4-6 | C. | | ..... | * | A | 3 | Cardamine .......... | 105 | Rhenogovia. |
| 3-313 | ....... | 60 | 2 | * | ∞-(16-20) | ..... | .... | A | 3 | Pastinaca .......... | 228 | France and Belgium. |
| 3-449 | ....... | 60 | 1.2 | — | — | * | .... | .... | 3 | Dipsacus .......... | 274 | Belgium. |
| 3- 67 | ....... | 60 | 1.5 | * or C. | — | ..... | * | A | 1 | Crataegus .......... | 126 | France, Italy, Germany. |
| 3- 71 | ....... | 60 | 3.5 | 2 | ∞ | ..... | * | A | 1 | Pyrus .......... | 126 | Europe. |
| 10-115 | ....... | 60-65 | 1-1.5 | C. | | * | * | A | 1 | Centaurea .......... | 280 | France. |
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| 3-489 | ....... | 60-65 | 3.5-5 | 3-5 | — | ..... | * | A | 4 | Graminae .......... | 19 | France, Italy, England. |
| 3-284 | ....... | 60-65 | 4-4.5 | 3 | — | ..... | * | A | 3 | Ranunculus .......... | 91 | Italy. |
| 3-523 | ....... | 60-70 | 1.75-2 | — | — | ..... | .... | A | 1 | Carex .......... | 20 | Italy, France. |
| 3-518 | ....... | 60-70 | 1.5 | C. | 4-6 | * | * | A | 1 | Carex .......... | 20 | "Arduennis." |
| 3-307 | ....... | 60-70 | 1 | * | — | ..... | * | A | 1 | Cucurbita .......... | 275 | Portugal, North America. |
| 22- 20 | 30-50 | 60-70 | 1.5-2 | C. | | ..... | .... | A | 1 | Silene .......... | 87 | Northern Italy. |
| 14- 25 | ....... | 60-70 | 2-2.5 | ∞ | ∞ | ..... | * | A | 4 | Acer .......... | 163 | Germany. |
| 3-105 | ....... | 60-70 | 2 | — | * | ..... | .... | A | 1 | Vaccinium .......... | 233 | U. S. A. (S. Car.). |
| 3-205 | ....... | 60-70 | 2-3 | *? | — | * | .... | A | 3 | Orobus .......... | 126 | Italy. |
| 18- 84 | 50-70 | 60-70 | 3.5 | ∞ | * | ..... | * | 39 | 6 | Striatiotes .......... | 17 | Holland. |
| 3-507 | 1/7 mm. | 60-70 | 5-6 | 6-7 | * | ..... | * | .... | 3 | Phragmites .......... | 19 | Northern Italy. |
| 18- 80 | 190-240 | 60-70 | 5 | 4-6 | * | ..... | * | A | 3 | Muscarum .......... | 39 | Italy. |
| 10- 17 | ....... | 60-70 | 3.5-4 | 2 | — | ..... | * | A | 1 | Sorbus .......... | 126 | Germany. |
| 3-135 | 150 | 60-75 | 2.5 | — | — | ..... | * | .... | ... | Hippophae .......... | 215 | France. |
| 11- 18 | ....... | 60-75 | 2-3 | ∞ | — | ..... | .... | A | ... | Eurya .......... | 186 | Ecuador. |
| 3-473 | ....... | 60-80 | ........ | 10-13 | 10-13 | ..... | .... | A | 3 | Spartium .......... | 19 | Belgium. |
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| 14- 51 | ....... | 60-80 | 2-2.5 | C. | * | ..... | * | A | 1 | Mertensia .......... | 252 | Greenland. |
| 22- 23 | ....... | 60-82 | 2 | 1-5 | — | ..... | * | .... | ... | Melandrium .......... | 87 | Montenegro. |
| 16- 41 | ....... | 60-90 | 1-1.5 | 0 | — | * | .... | A | 1 | Endlichera .......... | 270, 280 | Brazil. |
| 10- 37 | ....... | 60-90 | 5 | 5-6 | — | ..... | * | A-35 | ... | Melastoma .......... | 223 | China (Sangchan Sinarum). |
| 18- 48 | 90-120 | 60-100 | 2-3 | C. | ∞ | * | .... | A | 1 | Sherardia .......... | 270 | Italy. |
| 22-148 | 150-300 | 60-100 | 2.5-3.5 | — | * | ..... | * | A | 1 | Distichlis .......... | 19 | Argentina. |

| Volume No. Species No. | Diameter of Pycnidium. | Length of Spores. | Diameter of Spores. | Number of Septa. | Number of Guttulae. | Spores straight. | Spores curved. | Color of Spores. | Shape of Spores. | Host Genus. | Family Number. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3–556 | ....... | 60–100 | 10–12 | 1 | * | * | * | A | 3 | Agave ............ | 40 | Argentina. |
| 16– 99 | ....... | 60–100 | .5–1 | — | — | ..... | * | .... | ... | Psamma .......... | 19 | Denmark. |
| 3–568 | ....... | 63–114 | 3 | — | * | ..... | .... | A | 1 | Smilax ............ | 38 | U. S. A. (Pa.). |
| 3–197 | ....... | 64 | 4 | 3–7 | — | ..... | .... | A | 1 | Hosackia .......... | 128 | U. S. A. (Cal.). |
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| 18– 16 | 100–150 | 65–80 | 1.5–1.8 | 4–6 | — | ..... | * | A | 1 | Citrus ............ | 137 | Brazil (Sao Paulo). |
| 22–139 | 140–180 | 65–90 | 3.5–4 | 5 | * | ..... | * | 23 | 3 | Scirpus ........... | 20 | Hungary. |
| 11– 44 | ....... | 70 | 1.5–2 | — | — | ..... | .... | .... | ... | Cephalaria ........ | 274 | U. S. A.? |
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| 22–149 | ....... | 70 | 2–3 | * | — | ..... | .... | .... | 1 | Elymus ........... | 19 | Switzerland. |
| 22–107 | ....... | 70–75 | 2.5–3 | *? | — | ..... | .... | .... | 3 | Solanum .......... | 256 | Italy. |
| 10–201 | 70 | 70–75 | 3 | — | — | ..... | * | A | 3 | Eriophorum ....... | 20 | India (Nowaja Semlia). |
| 3–288 | ....... | 70–80 | 4 | 4–6 | — | ..... | * | A | 3–6 | Clematis .......... | 91 | England, Italy, Austria. |
| 14– 13 | 150 | 70–80 | 1.5 | C. | * | ..... | * | A | 1 | Epilobium ........ | 224 | Northern Italy. |
| 3–319 | 150 | 70–80 | 3–4 | — | 6–7 | ..... | * | A | 3 | Aegopodium ....... | 228 | Germany. |
| 3– 62 | ....... | 70–90 | 3–4 | — | — | ..... | .... | A | 6 | Rosa ............. | 126 | Europe, Italy. |
| 3–254 | ....... | 70–90 | 3.5–4.5 | — | — | ..... | .... | .... | 9 | Stellaria .......... | 87 | Malmedy. |
| 18– 90 | 275 | 70–90 | 2.5–3 | *? | * | ..... | .... | A | 1–3 | Eriophorum ....... | 20 | Alaska. |
| 10–222 | ....... | 70–100 | ........ | C. | — | ..... | * | .... | 1 | Pteris ............ | ... | North America. |
| 10–138 | 75–100 | 70–110 | 1.5 | C. | — | ..... | * | A | ... | Solidago .......... | 280 | Canada. |
| 3–351 | ....... | 70–110 | 3 | 3–∞ | — | ..... | * | A | 3 | Solanum .......... | 256 | Argentina. |
| 22– 69 | 100–150 | 70–120 | 3 | 5–9 | — | ..... | * | A | 3 | Phlox ............ | 250 | Italy. |
| 22– 71 | 200–300 | 70–130 | 2.5–3 | 5 | — | ..... | * | A | 1 | Convolvulus ....... | 249 | Russia. |
| 3– 49 | ....... | 75 | ........ | — | — | ..... | .... | .... | 1 | Rhus ............. | 153 | U. S. A. (New Eng., N. Y.). |
| 3–506 | ....... | 75–85 | 1 | — | — | ..... | .... | A | 1 | Andropogon ....... | 19 | Northern Italy. |
| 3–527 | 250–330 | 75–85 | 3–3.5 | 10–12 | ∞ | ..... | * | A–23 | 3 | Scirpus ........... | 20 | France. |
| 3–560 | ....... | 75–100 | 2 | C. | | ..... | .... | A | 1 | Convallaria ....... | 39 | Austria, Sweden, Italy. |
| 11– 62 | 150–200 | 75–100 | 6–8 | ∞ | — | ..... | .... | A | ... | Celtis ............ | 63 | U. S. A. (Kan.). |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 22- 45 | 80-120 | 80-100 | 1-1.5 | — | 0 | ..... | * | A | 1 | Erythrophleum .... | 128 | Africa (tropical). |
| 3-423 | ....... | 80-100 | 2-2.5 | *? | — | ..... | .... | A | 1 | Bellis ............ | 280 | Northern Italy. |
| 10- 78 | ....... | 80-100 | 3-4 | — | — | ..... | * | A | 3 | Lathyrus .......... | 121 | France. |
| 22-129 | 180-250 | 80-100 | 2.5-3.5 | ∞ | — | * | * | A | 1 | Ornithogalum ..... | 39 | U. S. A. (Del.). |
| 18- 92 | 100 | 80-110 | 2.5-3 | 1-3 | — | ..... | .... | A | 1-6 | Munroa ........... | 19 | U. S. A. (Kan.). |
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| 10- 64 | 104 | 82-108 | 4 | — | — | ..... | * | A | 3 | Quercus .......... | 62 | U. S. A. (Fla.). |
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| 3-234 | ....... | 90 | 3.5-4 | 4 | — | ..... | * | A | 3 | Dictamnus ........ | 137 | Europe. |
| 3-541 | 120-150 | 90 | 3 | — | ∞ | ..... | .... | A | 3 | Alisma ............ | 15 | Northern Italy. |
| 3- 58 | ....... | 90-100 | 3.5 | ∞ | — | ..... | * | A | ... | Cytisus ........... | 128 | Italy and France. |
| 10-131 | 11 | 100-110 | ........ | — | — | ..... | * | A | 1 | Aster ............. | 280 | N. America. |
| 3-425 | 200-300 | 100-130 | 4-5 | *? | ∞ | ..... | .... | A | 1 | Leucanthemum .... | 280 | Italy and Portugal. |
| 3-195 | ....... | 120 | 3 | 9-10 | — | ..... | * | A | 1 | Astragalus ........ | 128 | Europe. |
| 10-208 | ....... | 120-130 | 2-2.5 | 9-12 | ∞ | ..... | * | A | 1-4 | Scirpus ........... | 20 | Scotland. |
| 22-128 | 120-150 | 120-130 | 2-3 | 3 | — | ..... | * | A | 3 | Podocarpus ....... | 91 | Italy. |
| 22- 39 | 180-220 | 120-160 | 3-4 | 7-13 | — | * | * | A | 1 | Anthyllis ......... | 21 & 87 | Italy. |
| 11- 77 | 80 | 140 | 2 | — | ∞ | ..... | .... | A | 1 | Dictyota? ......... | | Celebes Islands. |
| 22-110 | 150-225 | 150-240 | 3-4 | *? | — | ..... | * | A | 1 | Vaccinium ........ | 233 | N. America. |

## FAMILIES ARRANGED ALPHABETICALLY WITH THE FAMILY NUMBER

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163. Aceraceae
204. Achariaceae
272. Adoxaceae
84. Aizoaceae
15. Alismaceae
79. Amaranthaceae
40. Amaryllidaceae
153. Anacardiaceae
209. Ancistrocladaceae
98. Anonaceae
247. Apocynaceae
13. Aponogetonaceae
157. Aquifoliaceae
23. Araceae
227. Araliaceae
74. Aristolochiaceae
248. Asclepiadaceae

73. Balanophoraceae
58. Balanopsidaceae
168. Balsaminaceae
86. Basellaceae
81. Batidaceae
208. Begoniaceae
2. Bennettitaceae
93. Berberidaceae
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194. Bixaceae
177. Bombacaceae
252. Boraginaceae
32. Bromeliaceae
119. Brunelliaceae
122. Bruniaceae
49. Burmanniaceae
139. Burseraceae
16. Butomaceae
149. Buxaceae

210. Cactaceae
148. Callitrichaceae
96. Calycanthaceae
279. Calyceraceae
276. Campanulaceae
197. Canellaceae
47. Cannaceae
107. Capparidaceae
271. Caprifoliaceae
205. Caricaceae
183. Caryocaraceae
87. Caryophyllaceae
51. Casuarinaceae
158. Celastraceae
27. Centrolepidaceae
116. Cephalotaceae
89. Ceratophyllaceae
262. Cesneriaceae
90a. Cercidiphyllaceae
78. Chenopodiaceae
172. Chlaenaceae
54. Chloranthaceae
193. Cistaceae
230. Clethraceae
136. Cneoaceae
195. Cochlospermaceae
263. Columelliaceae
221. Combretaceae
33. Commelinaceae
280. Compositae
127. Connaraceae
249. Convolvulaceae
3. Cordaitaceae
151. Coriariaceae
229. Cornaceae
156. Corynocarpaceae
115. Crassulaceae
125. Crossosomataceae
105. Cruciferae
217a. Crypteroniaceae
275. Cucurbitaceae
120. Cunoniaceae
34a. Cyanastraceae
1. Cycadaceae
22. Cyclanthaceae
82. Cynocrambaceae
226. Cynomoriaceae
20. Cyperaceae
154. Cyrillaceae

207. Datiscaceae
235. Diapensiaceae
146. Dichapetalaceae
78a. Didiereaceae

FAMILIES ARRANGED ALPHABETICALLY WITH THE FAMILY NUMBER—Continued

180. Dilleniaceae
43. Dioscoreaceae
274. Dipsacaceae
188. Dipterocarpaceae
112. Droseraceae

240. Ebenaceae
215. Elaeagnaceae
171. Elaeocarpaceae
189. Elatinaceae
150. Empetraceae
234. Epacridaceae
233. Ericaceae
30. Eriocaulaceae
134a. Erythroxylaceae
123a. Eucommiaceae
181. Eucryphiaceae
147. Euphorbiaceae

62. Fagaceae
199. Flacourtiaceae
25. Flagellariaceae
192. Fouquieriaceae
190. Frankeniaceae

211. Geissolomaceae
246. Gentianaceae
129. Geraniaceae
4. Ginkgoaceae
265. Globulariaceae
7. Gnetaceae
100. Gomortegaceae
173. Gonystylaceae
277. Goodeniaceae
19. Gramineae
70. Grubbiaceae
187. Guttiferae

39. Haemodoraceae
225. Halorrhagidaceae
123. Hamamelidaceae
103. Hernandiaceae
164. Hippocastanaceae
159. Hippocrateaceae
225a. Hippuridaceae
133. Humiriaceae
80. Hyctasinaceae
76. Hydnoraceae
17. Hydrocharitaceae
251. Hydrophyllaceae
114. Hydrostachyaceae

162. Icacinaceae
44. Iridaceae

60. Juglandaceae
60b. Julianaceae
14. Juncaginaceae
36. Juncaceae

196. Koeberliniaceae

254. Labiatae
55. Lacistemaceae
97. Lactoridaceae
92. Lardizabalaceae
102. Lauraceae
219. Lecythidaceae
128. Leguminosae
59. Leitneriaceae
24. Lemnaceae
232. Lennoaceae
264. Lentibulariaceae
38. Liliaceae
152. Limnanthaceae
132. Linaceae
206. Loasaceae
245. Loganiaceae
67. Loranthaceae
216. Lythraceae

95. Magnoliaceae
202. Malesherbiaceae
141. Malphighiaceae
175. Malvaceae
48. Marantaceae
184. Marcgraviaceae
260. Martyniaceae
28. Mayacaceae
223. Melastomataceae
140. Meliaceae
167. Melianthaceae
94. Menispermaceae
101. Monimiaceae

FAMILIES ARRANGED ALPHABETICALLY WITH THE FAMIL
NUMBER—Continued

64. Moraceae
109. Moringaceae
45. Musaceae
57. Myricaceae
267. Myoporaceae
99. Myristicaceae
121. Myrothamnaceae
236. Myrsinaceae
222. Myrtaceae
68. Myzodendraceae

12. Najadaceae
111. Nepenthaceae
255. Nolanaceae
80. Nyctaginaceae
88. Nymphaeaceae

224. Oenotheraceae
182. Ochnaceae
72. Olacaceae
243. Oleaceae
213. Oliniaceae
71. Opiliaceae
50. Orchidaceae
261. Orobanchaceae
130. Oxalidaceae

21. Palmae
9. Pandanaceae
104. Papaveraceae
203. Passifloraceae
259. Pedaliaceae
212. Penaeaceae
155. Pentaphylacaceae
35. Philydraceae
268. Phrymaceae
83. Phytolaccaceae
6. Pinaceae
53. Piperaceae
231. Pirolaceae
118. Pittosporaceae
124. Platanaceae
269. Plantaginaceae
238. Plumbaginaceae
113. Podostemonaceae
250. Polemoniaceae
145. Polygalaceae

77. Polygonaceae
34. Pontederiaceae
11. Potamogetonaceae
85. Portulacaceae
237. Primulaceae
66. Proteaceae
218. Punicaceae

185. Quiinaceae

75. Rafflesiaceae
91. Ranunculaceae
31. Rapateaceae
108. Resedaceae
26. Restionaceae
169. Rhamnaceae
220. Rhizophoraceae
126. Rosaceae
270. Rubiaceae
137. Rutaceae

166. Sabiaceae
56. Salicaceae
244. Salvadoraceae
69. Santalaceae
165. Sapindaceae
239. Sapotaceae
110. Sarraceniaceae
52. Saururaceae
117. Saxifragaceae
257. Scrophulariaceae
179. Scytopetalaceae
138. Simarubaceae
256. Solanaceae
217. Sonneratiaceae
10. Sparganiaceae
200. Stachyuraceae
160. Stackhousiaceae
161. Staphyleacaceae
37. Stemonaceae
178. Sterculiaceae
278. Stylidiaceae
241. Styracaceae
242. Symplocaceae

42. Taccaceae
191. Tamaricaceae

FAMILIES ARRANGED ALPHABETICALLY WITH THE FAMILY NUMBER—Concluded

| | | | |
|---|---|---|---|
| 5. | Taxaceae | 63. | Ulmaceae |
| 186. | Theaceae | 228. | Umbelliferae |
| 235a. | Theophrastaceae | 65. | Urticaceae |
| 30a. | Thurniaceae | | |
| 174. | Tiliaceae | 273. | Valerianaceae |
| 106. | Tovariaceae | 41. | Velloziaceae |
| 144. | Tremandraceae | 253. | Verbenaceae |
| 142. | Trigoniaceae | 198. | Violaceae |
| 176. | Triplochitonaceae | 170. | Vitaceae |
| 18. | Triuridaceae | 143. | Vochysiaceae |
| 90. | Trochodendraceae | | |
| 131. | Tropaeolaceae | 29. | Xyridaceae |
| 201. | Turneraceae | | |
| 8. | Typhaceae | 46. | Zingiberaceae |
| | | 135. | Zygophyllaceae |

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# PROGRESS IN BARBERRY ERADICATION IN ILLINOIS DURING 1919.

By L. R. Tehon, United States Department of Agriculture, Urbana.

The barberry eradication campaign had its beginning, in the state of Illinois, in the spring of 1918 under the leadership of Dr. F. L. Stevens and Dr. H. W. Anderson. The results of the year of 1918, briefly restated from Dr. Anderson's report, indicated 36,419 bushes found. Dr. Anderson's report states confidently that "seventy per cent of all of the barberries in Illinois have been removed, or will be removed before next spring". Dr. Anderson likewise speaks of bushes escaped from cultivation as follows: "It is evident, however, that the shrub is not very widely distributed in the woods and pastures to date". As it now appears, these last two statements by Dr. Anderson were far too optimistic.

The campaign of 1919 opened in March under the leadership of Dr. F. E. Kempton, Dr. F. L. Stevens resigning his place in favor of Mr. P. A. Glenn, Chief Inspector for the State Division of Plant Industry. Dr. Kempton left Illinois to become federal leader of the campaign on June 30, 1919; and was succeeded by L. R. Tehon.

Through provisions contained in the Plant Inspection Act of 1917, as amended in 1919, the common barberry and the purple-leafed barberry were declared a nuisance by the state Director of Agriculture, after a public hearing held on August 9th.

The plan of the campaign during the past year has been different from that of the first year. The slogan "Barberry or Bread" has been dropped, and no attempt has been made to cause this campaign to appear as anything other than one of the many campaigns for agricultural improvement through plant disease control. Use has not been made of high school students or other persons who were not employed by the United States Department of Agriculture in the immediate tasks of scouting for, and removing located, barberries. The number of men employed has varied from one in March and December to twelve in July. The plan of the campaign has been to assign a squad of men to a county and to work thoroughly every town in that county. The start was made in the northern part of the state and made good progress southward reaching Pike county in the west, Sangamon, Christian, and Macon counties in the center and Crawford and Lawrence counties in the Wabash Valley. The countryside is as yet very largely untouched, although a great deal of accurate data has been collected. Single towns in other portions of the state have also been worked.

From March 1st until December 31st, the amount accomplished has been entirely satisfactory both to the State Department of Agriculture and to the United States Department of Agriculture. The tangible progress of the year may be summed up in the following: The number of towns visited was 632; the approximate population reached was 1,169,200; barberries were found on 2,977 properties and eradicated from 2,921; the number of bushes found was 45,370 and the number eradicated 39,879. About 350 towns, distributed among about 60 counties, are known to be free from *Berberis vulgaris* and the variety *purpurea.*

Infected barberry was found in or near 54 towns, distributed among 18 counties. The total number of infected bushes found was 2,859; the earliest date of reported infection was May 2nd at Winnebago, in Winnebago county. The latest date of reported infection was on September 2nd at Cornell, in Livingston county. The most southerly point of infection reported was at Bayles, in Pike county.

The future work of barberry eradication remains to be done in the country districts, and finally in a clean-up of areas of dense population such as Chicago, Evanston, and East St. Louis. And the importance of this part of the program is not by any means small.

The accompanying map shows the location, and indicates the relative extent, of "escaped" or "wild" plantings. Dr. Anderson's statement relative to escaped barberries will be remembered. It is worthy of note that after two years of work there have come to our attention, without special emphasis being laid on that phase, at least 33 localities in which barberry is now growing wild. Dr. Anderson mentions only a single planting of escaped bushes in his 1918 report. Considerable interest obtains in regard to several of these plantings.

The country surrounding Galena (Jo Daviess county) seems to be an ideal habitat. One of our men writes that "the country about Galena is full of the pest. It would take a week for two men to get a thorough survey. The rocks and hills are ideal for barberry and they are found growing nice and big with beautiful red berries. Some of the farmers told me they use the leafy branches for feeding sheep, goats, etc., in winter. I would suggest that either this fall or next spring a couple of good men were sent out to do a good job. The farmers are very willing to cooperate".

During the past year, rust infection of wheat was particularly severe in Hancock county. Had it not been for dry weather and consequent early maturity of the grain a large percentage of loss would undoubtedly have occurred. Mr. Curtiss, in working this county, was able to locate a 500 acre tract of wooded hill land on the Mis-

sissippi near Hamilton in which large numbers of barberry are growing wild.

On November 22nd, one of our men visited Kankakee. His first letter reports rumors of a place where "there are millions growing wild!" and when his report came in for properties on which they actually occurred, he was able to show at least six properties and, at the most conservative estimate possible, 250 bushes. This was merely incidental to working the town of Kankakee.

Probably the most interesting area in which barberry has escaped from cultivation is in Knox county. The town of Henderson, a small village of about 160 inhabitants, was first settled in 1825. A few hedges were planted in the town by the early settlers, and those hedges up to the present year, were still in existence. Our field man, who at that time had established temporary headquarters in Galesburg, writes as follows: "When I went out there (Henderson) yesterday, I had the idea that one hours work would be sufficient, but found that it took two days. I found about 1,200 bushes altogether. The whole township is "infested" with barberries; and the bushes are large and growing wild. Mr. W. has timberland of 200 acres and the bushes are scattered all over it. Messrs. W., M., P., C., and P., also have a considerable amount. It seems that the "wild" bushes have been propagated from seed from the original hedges."

One instance of particular interest has come to our attention during the past summer as showing how the barberry may be of importance in the spread of rust to grains other than wheat.

*Puccinia graninis avenae* is the biological form on oats, *tritici* for rust on wheat. On a farm belonging to J. H. near Minooka, Illinois there was a rusted hedge of the common barberry approximately two hundred yards long containing about 600 bushes. The accompanying sketch, reproduced as clearly as possible from a field drawing, represents the relative positions of the several fields with respect to the barberry. The winter wheat directly east of the barberry was well protected by the intervening orchard. This fact, together with the earlier develop-

ment of the winter wheat, has resulted in a comparative freedom from rust.

About one-quarter of a mile south-east of the barberries, however, was a field of spring wheat with no protection from the infected barberry save distance. A pasture abutting upon the hedge extended southward, coming close to the wheat. *Hordeum jubatum* (squirrel tail) and *Agropyron repens* in the pasture were severely rusted. Rust had spread first from the hedge to the pasture grasses, and then from the hedge and pasture grasses to the spring wheat producing ninety per cent infection.

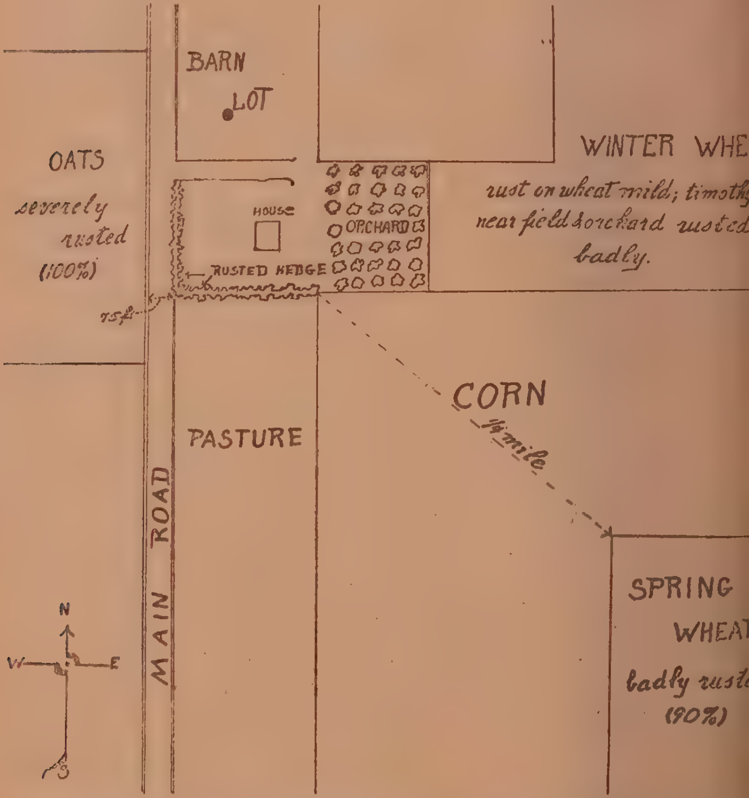
Directly across the road, and not seventy feet distant from the infected hedge, was a field of oats in which not a single stalk was free from rust. Grasses along the road and along fences, particularly *Dactylis glomerata* and *Agrostis alba*, were heavily rusted. About one and an eighth miles south of the infected hedge was a second field of oats (not shown on the sketch) which was infected only to the extent of seventy-five to eighty per cent, this being due partly to the influence of the infected hedge in increasing infection in the fields and grasses near it. The presence of rusted timothy near the orchard indicates also the possible influence of the barberry in spreading the *phlei-pratensis* form of rust.

Careful microscopic examination was made of oats from the above fields to eliminate the possibility of the rust being *Puccinia coronata*. The removal of the hedge in this case has removed an important source of infection in this neighborhood both for wheat and oats. Further control of the grass-weeds in which the mycelium of the rust may be perennial should serve as a further means of control.

The results of our year's work have served to enhance the significance of barberry eradication as a means of rust control. A large portion of the bushes have been removed from the towns. The countryside remains yet to be done. Information has accumulated to show that the barberry is not only present in great numbers in cultivation in the country districts, but has escaped from cul-

tivation in many places and in considerable quantity

Now, after two years of work, and the knowledge tha the worth and size of the task is gradually becomin clear, comes the news that the campaign is no longer t receive support from the federal government.




The farm of J. H. near Minooka, Illinois showing the relationship be tween infected barberry and neighboring fields of wheat and oats

Illinois.


Showing lo-
cation and
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wild" plantings of
arberry known to be
resent in Illinois
revious to January
irst, 1920.

# FOREST DISTRIBUTION AT THE ENDS OF THE LAKE CHICAGO BEACHES

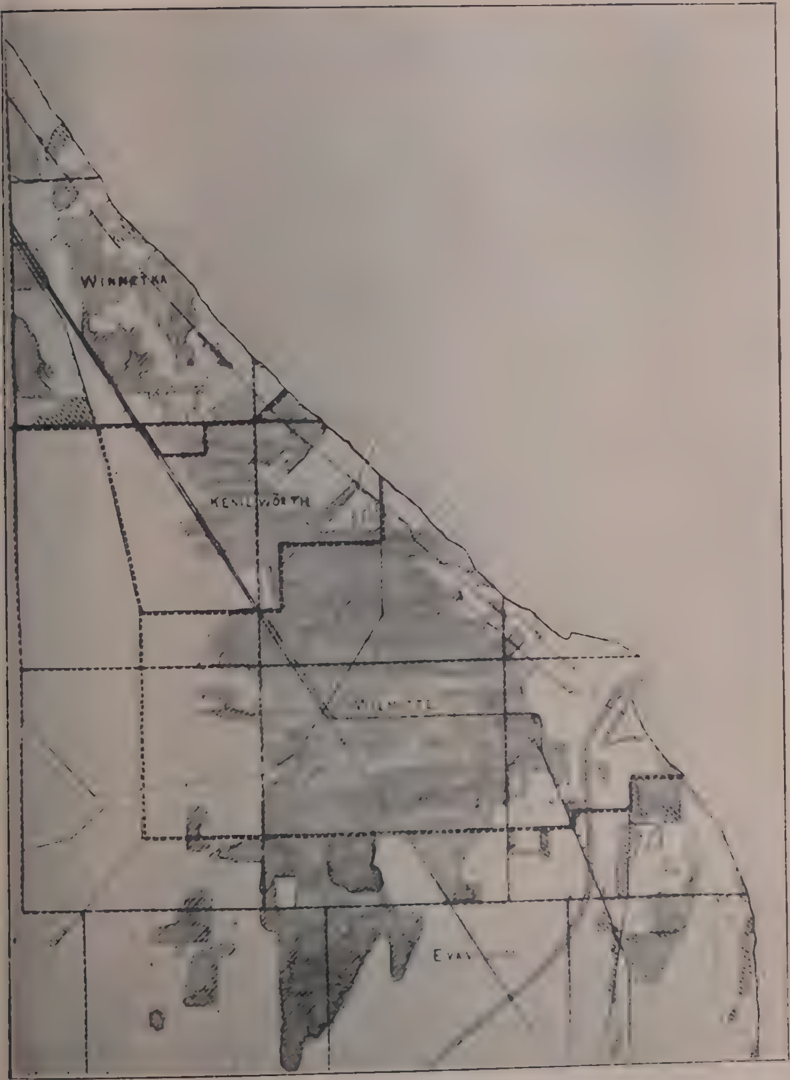
Lillian Marguerite Simmons, Northwestern University

## INTRODUCTION

The work for this study has been carried on in connection with an ecological survey of the same region. The problem undertaken is to determine the location and character of the present forest areas and from the results of this investigation to decide upon the nature of the more extensive forests which occupied this region in the past.

The area covered by the study extends along the shore of Lake Michigan a few miles north of Chicago and includes the northern part of Evanston, all of Wilmette and Kenilworth and the eastern part of Winnetka. Its general shape is somewhat triangular, the lake shore forming the north-east side, Simpson Street, Evanston the south, and the Gross Point Road and the section lines west of sections 16 and 21 of New Trier Township the west side. The area covers the eastern parts of sections 21, 28 and 33 in New Trier and of section 10 in Niles Township and all of sections 16, 22, 26, 27, 34 and 35 in New Trier, 11 and 12 in Niles and the northern section in Evanston Township. Section 12 of Niles Township is sometimes included as part of Evanston Township, being within the limits of the City of Evanston. Several of these sections are not complete, the north-eastern portions being cut away by the lake (Figure 1.)

This region has been settled for a long time and consequently the natural conditions have been more or less disturbed. The eastern portion at the present time is largely a residence section while the land on either side of the Gross Point Road is under cultivation in truck farms and greenhouses. Because of the building of towns throughout the sections, the natural physiographic and vegetational features have been obscured and in many places destroyed by draining, grading and cultivation.




Distribution of Forests

Mesophytic Upland Forest

Xerophytic Sand Ridge Forest

Morainic Swamp Forest

### A. LITERATURE

There has been little study made of the forests of this region. Hall and Ingall (7) describes the forests of the northern part of the state, but they made a detailed study of only the uplands of Pike, Calhoun and Jo Daviess counties and the bottomlands along the Mississippi and Illinois Rivers. Cowles (5) has described the vegetation of the Chicago region dividing it into three general types depending upon soil and topographic conditions: the mesophytic upland forest on morainic clay, the hydrophytic lakes and swamps and mesophytic prairies of the Chicago plain and the xerophytic forests of the dunes and ridges. The plant associations found in the area studied come under these general types and the lists of characteristic trees and undergrowth given by Cowles are very valuable.

A similar ecological study has been made of the northern part of Glencoe by Hazel M. Schmoll (11), but her section lies on the morainic upland and does not include any of the Chicago plain and the ridges, which compose the greater part of the Evanston-Winnetka area. Ulrich's study of conditions in the McLeish ravine at Glencoe (13) and Sherff's of the vegetation of the Skokie Marsh (12) also deal with conditions not found in this area.

The only articles which deal directly with the vegetation of this region are those by residents of Evanston and are very enlightening as to the former conditions there. C. B. Atwell (1) in an address before the Evanston Historical Society, described the forests on and between the ridges of Evanston, comparing the different types. Otherwise there has been no investigation made.

### B. METHODS

The general limits of the area to be covered in this study were chosen to include the ends of the beaches of Lake Chicago and the land between them. The lines were rather arbitrarily drawn, but an investigation of the forests beyond the borders of the area showed that

they were similar to those studied, where the conditior were the same.

A map of the area was made, built up from the top graphic map of the Evanston quadrangle and from th maps of the various towns included. Owing to admi ted discrepancies in the topographic sheet and to th lack of a definite scale of miles in the city maps, certai defects are known to occur in the resulting map, eve extending so far as to the possible location of some the section lines. The map is, however, as nearly co rect as it was possible to make it and its value is n seriously impaired.

The larger forest areas were located on this map ar the position of individual forest trees noted. A mo intensive study was then made of the typical areas which the natural vegetation was least disturbed, or those which appeared unusual. The chief points co sidered were the composition of the forest area, bo in trees and undergrowth, and its general topograph position, the nature of the soil, drainage condition light, exposure and any other factors which might d termine that composition. From the results of these i vestigations and from any other information availab conclusions were drawn as to the probable extent of t original forests before their destruction.

Several difficulties were encountered in making th investigation, one being the possible error in decidi which trees should be considered members of the ori inal forest. All oaks, hickories, and butternuts and su elms, maples, ashes, lindens, cherries, birches and ceda as by their size, apparent age, and location indica their presence naturally, were noted as forest trees. M Currey (6) however, in the "Plan of Evanston", stat that many of the trees of Evanston were planted by t early settlers, being imported from the "Big Wood two or three miles west for that purpose. If such is t case, there may be some errors in determining the lin of the original forest, but as most of these trees we elms and maples which are not used as absolute criter the results should not be far from correct.

Another difficulty was in identifying the difficult species of oaks. The red oaks are so much alike that it is almost impossible to distinguish between them without special study. An investigation is being carried on, at the present time, by some of the students of Northwestern University, under the direction of Dr. W. G. Waterman, to determine the relative proportions of Quercus rubra, Q. velutina and Q. ellipsoidalis in this vicinity. The white oaks of the region, Quercus alba, Q. macrocarpa and Q. bicolor are more distinct species, though even with them identification is sometimes uncertain in individual cases where leaves and acorn cups can not be had for comparison. But in general, the reported distribution of the species of white oaks may be considered reasonably correct.

## Physiography

### A. Geology

The whole of the region, with the exception of the portion west of the Gross Point Road and its extension north, is located upon the Chicago plain, which was once a part of the floor of Glacial Lake Chicago. The history and description of this plain are given fully by Bannister (3), Leverett (9), Salisbury and Alden (10) and especially by Atwood and Goldthwait (2), so that only the essential features need be discussed here.

As the continental glacier receded from the Lake Michigan trough and the country round about, it appears to have left at its foot a large body of water which extended over a greater territory than the lower end of Lake Michigan and is appropriately called Lake Chicago. Due to possible tilting, changes in outlet and other causes the recession of the lake was not gradual but there were three stages at which the waters of the lake stood for a long time, each stage having its trace in beaches and bars on the lake plain as it was exposed.

At the earliest, or Glenwood stage, the water stood sixty feet higher than the present level of Lake Michigan. The beach can be traced from the water works

at Winnetka, along the east side of the ridge, which th Gross Point Road follows, to a point south of Winnetk where it turns west and north. South from this poir a low sand bar was built by the action of the waves an current, almost cutting off the mouth of an embaymer to the west which is called the Skokie Bay.

The second, or Calumet, beach follows closely the lir of the first and continues along the east side of the Glei wood bar. At this stage, when the lake was twenty fe lower than at the Glenwood stage, or about forty fe above Lake Michigan, a second bar was built, whic seems to have extended from some point northeast of tl present shore line, southwest to the Rose Hill Cemeter in Chicago. This Rose Hill bar, as it is called, appear at the Wilmette harbor and is followed by Ridge Avenu Evanston. Between it and the Calumet beach proper wa another shallow stretch of water known as the Wilmett Bay.

The Tolleston beach, the latest of the three, appear at the lake on the Northwestern campus and extenc southwest approximately parallel to the others. At tl time of the formation of this beach, the lake stood abou twenty feet above the present lake level. Sever slightly lower ridges and the Tolleston bluff are me tioned by Goldthwait, but these do not appear in tl territory covered.

Finally the lake fell to the present level and is no causing the destruction of the land which was former part of its floor. It seems evident that it has alreac worn away a large amount for it is cutting into the o morainal clay of the upland between Winnetka ar Waukegan, all traces of the three beaches having bee entirely obliterated. The Tolleston beach, indeed, ha been destroyed between Evanston and Waukegan.

### B. TOPOGRAPHY

In general, then, the topography is that of a fair level plain, sloping from the foot of a bluff at the nort west and interrupted by sand ridges parallel to the blu At the north is the morainic upland, descending in pe

ceptible steps to the Skokie Marsh, west of the region. The eastern line of the upland is the Glenwood bluff, starting at the lake south of North Avenue, Winnetka and swinging west and south to the C. & N. W. Ry. which crosses it at about Willow Street. South of this it is followed by the Gross Point Road which continues along the bar built out from the end of the ridge.

From this ridge the land slopes east more and more gradually to the lake where it ends in a steep bluff about thirty to forty feet high. There is also a slight descent toward the south. The second ridge, starting at the Wilmette harbor follows a line a little west of south. It rises ten to twenty feet above the land on either side, which drops away with a gentle slope. A short spur extends northwest from this ridge just north of Maple Avenue, Wilmette. East of the ridge the slope is again to the south and east for the northern portion where the Calumet and Tolleston ridges approach each other is higher. The slope is greater on the west side of the Calumet ridge for here the old Wilmette Bay was protected by the bar.

The Tolleston ridge rises only about five or ten feet above and is not clearly defined north of Simpson Street as the eastern side has been eroded by the lake. A narrow strip of sand and gravel forms the beach below the wave-out bluff which increases from about fifteen feet at this point in Evanston to over sixty feet in Winnetka where the upland appears.

The whole region is underlain by the unworked glacial till covered along the ridges and in local areas by deposits of more or less stratified sand and gravel. The crests and slopes of the ridges are well drained, but drainage in the clay lowlands is very poor and wherever minor depressions occur, water stands for a long time in the spring. An attempt has been made to remedy this condition by the digging of various small drainage ditches and of the North Shore Channel, but numerous small swampy areas still exist.

Some idea of conditions in this region before it was artificially drained is given by Frances Willard (14),

who says that at about 1865 the part of Evanston nort of Church Street and west of Chicago Avenue was marsh standing partially under water for several month of the year. This tract, she says, was later drained an made habitable by her father. In describing Evanston at the founding of Northwestern University, Mary Louis Childs (4) also speaks of this swamp and says that practi cally all of Evanston was a swamp with a few groves o oaks and maples on the higher ground. Such a patch i that now included in the Northwestern University cam pus. These swamp conditions extended to the bluff a Winnetka and the present towns of Evanston, Wilmett and Kenilworth would have been impossible without ar tificial drainage.

## Investigation

### A. Associations

A large part of this region is still covered by an ex tensive forest which may be divided into three distinc associations, characterized by the predominance of cer tain tree species and by the accompanying undergrowth the upland oak-hickory, a more or less xerophytic san ridge type and the morainic swamp forest. The asso ciations of the Chicago Region have been described b Cowles (5) and his classification is followed here.

No great attempt has been made to differentiate be tween the types of red oaks, Quercus rubra, Q. Velutin and Q. ellipsoidalis, for, as it has been said, it is ver difficult to distinguish the species. In general, Quercu velutina (Q. coccinea-tinctoria of Cowles) seems to occu very sparingly, while Q. rubra and Q. ellipsoidalis ar found in all the associations in varying proportions. Q coccinia, mentioned by Cowles as a member of the swam forest, is not found in this region.

The upland oak-hickory association on the morain west of the Glenwood beach, is composed chiefly of th white and bur oaks (Quercus alba and Q. macrocarpa with a small proportion of red oaks, hickories (Cary ovata) and a few scattered black cherries (Prunu

serotina.) There is little undergrowth remaining, but in a part of the forest beyond the arbitrary boundary line are Prunus virginiana, Podophyllum, Viola, Geranium and Trillium recurvatum.

In the xerophytic sand ridge forest, the red oaks, Quercus macrocarpa and Quercus alba are the chief types. The proportions vary but, on the whole, the red oaks are the more common. The shagbark hickory and the black cherry are also found in smaller numbers and one large black walnut (Juglans nigra) stands at the corner of Pine Street and Maple Avenue, Winnetka. The undergrowth is very slight, lacking in shrubs, and consists of the more xerophytic herbs, as Smilacina racemosa, Trillium recurvatum, Viola, Antennaria, Achillea, Fragaria and Potentilla.

The morainic swamp forest, which is the most extensive, and also the least disturbed, varies in composition in localized areas, but the swamp white oak (Quercus bicolor) is dominant everywhere. Other trees typical of the swamp forest are the butternut (Juglans cinerea), elm (Ulmus americana), ash (Fraxinus americana), linden (Tilia americana), white maple (Acer saccharinum), and various haws (Crataegus sp.) although they do not occur in such large numbers. The red oaks and Carya ovata are also members of this forest. The undergrowth is very luxuriant with young trees, Prunus virginiana, Rosa, Sambucus canadensis, Ribes, Rubus, Xanthoxylum americanum, Rhus toxicodendron, Celastrus scandens, Vitis, Ampelopsis quinquefolia, Smilax hispida, Viola sp., Trillium grandiflorum, T. recurvatum, Claytonia, Geranium, Phlox, Anemone, Sanguinaria, Cardamine bulbosa, Ranunculus sp. Smilacina racemosa, Podophyllum, Maianthemum, Allium, Fragaria, Galium, Thalictrum, Osmorrhiza, Iris and others.

### B. DISTRIBUTION

The upland forest is found only in the northwest corner of the region studied, on the morainal till west of the Glenwood bluff. Only small areas appear in this region,

as shown on the map (Figure 2) but they are continuou with a larger forest west of the arbitrary boundary line.

Along the crests and slopes of the ridges are scattere areas of the xerophytic ridge forest. The land has bee cleared along the Gross Point Road leaving only an are north of Winnetka Avenue and a small group of tree south of Central Street, but the forest is more continu ous along Ridge Avenue and the lake shore in Evanston where it has been less disturbed. Other isolated area are found along the lake shore in Winnetka and one V shaped patch north of the Northwestern University ath letic field.

The greater part of the land between the Glenwoo and Calumet ridges is occupied by the morainic swam forest. This covers the western part of the residenc section of Evanston and nearly all of Wilmette an Kenilworth and extends into Winnetka. The outline of the central area are very irregular and there ar smaller patches outlying on the east and west. A som what similar but less extensive forest lies between th Calumet and Tolleston ridges.

Although the typical sections of the different associa tions are very dissimilar, there is in certain places transition from one association to another, so gradua that a line can hardly be drawn between them. Thus forest area may be classed as one type on the map, whe it is apparently intermediate between that type and an other. Such an area is the one at Winnetka Avenu west of the Gross Point Road. It is classed as xerophyti because of its location on the slope of the ridge and be cause the red oaks are more numerous than the white (Quercus alba). It resembles the xerophytic forest o the Northwestern University campus south of Simpso Street, but is more mesophytic than the other areas o ridge forest in the region studied. The southern an western limit of this area were not determined.

It is possible also that in such a case the characteristi species have been removed or killed and the resultin type is not the natural one. This is especially likel where the remaining patch is small and the undergrowt

is wanting. Old residents of Evanston state that at one time the ridges were covered with a heavy forest in which the white oak was much more common and that lumbering was the first industry along the North Shore. The white oak, being excellent for building purposes, would be the first removed. Also the artificial conditions, due to the opening of the forest and draining, might destroy some species. Dr. Heminway (8) mentions this as one cause of the dying of the forest trees.

## DISCUSSION

The distribution of the forest associations is apparently closely related to soil and drainage conditions although other factors may enter in. The mesophytic upland forest requires a rich but fairly well-drained soil. Such a condition can only be found in this region on the moraine uplands and on them the forest is fully developed. Along the edge of the bluff where the exposure is greater and the conditions more xerophytic the red oaks increase in number and a few scattered birches (Betula alba), red and white cedars (Juniperus virginiana) and white pines (Pinus strobus) are to be found. The red cedars and birches appear to be natural but the Thuja occidentalis and Pinus strobus may have been introduced. No individuals whose presence naturally was absolutely certain were seen though Mr. Atwell (1) states that some white pines still remain from the old forest.

Where the soil is rather course and well-drained, as on the crests and slopes of the ridges the xerophytic forest reaches its highest development. The red oaks are on the whole the predominating species, but at the end of Pine Street, Winnetka, near the lake, is a patch consisting chiefly of bur oaks (Q. macrocarpa). There is no apparent reason for this, but Cowles (5) says the bur oak appears to be more abundant on the lower and less drained ridges. The difference in elevation in this case, however, is inappreciable.

The swamp forest is found on the lowland clay where the drainage is very poor. Its composition apparently

varies with the elevation, the red oaks increasing in number and the herbaceous vegetation becoming more xerophytic on the higher ground. An area of this type is located south of Central Street and east of Ridge Avenue. Here the trees are Quercus bicolor, red oaks, elms and ashes, and the undergrowth, Viola, Podophyllum, Fragaria, Potentilla, Allium, Smilacina and Trillium recurvatum.

Where the ground is lower the swamp forest reaches its climax. The most characteristic patch of this type lies between Colfax and Grant Streets and Bennett and Ewing Avenues in Evanston. This is called the "Lincoln Woods" and is now a part of the Cook County Forest Preserve. Other areas in which the forest is best preserved are in Wilmette near the Electric R. R. between Maple and Linden Avenues and at Chestnut Avenue between Tenth and Eleventh Streets. Nearly (everywhere,) however, the forest trees have been left standing on vacant property and in yards and along the streets. The herbaceous vegetation is also well preserved.

An interesting patch of swamp forest is located at the west side of Nanzig Avenue at the end of Isabella Street where Iris and Caltha palustris are found under red and bur oaks, Tilia, Crategus and Populus tremuloides. Iris was found in several other places in depressions and in shallow drainage ditches along the edge of the forest. Caltha was not found elsewhere although it was reported from the patch north of Winnetka Avenue, east of the New Trier High School.

Where the forest has been opened up or cut over and unused, Salix, Populus tremuloides, Cornus stolonifera and Crataegus appear. A typical growth is to be seen on Sheridan Road northwest of Winnetka Avenue.

The slopes of the Lake bluff are covered with Populus deltoides, Salix, Alnus incana and Rhus. At the foot of North Avenue Winnetka, a small clump of Juniperus communis has taken a foot-hold half way down the slope. This has probably been imported from the Waukegan region where it is common, as has the patch

on the end of the Calumet ridge at the Wilmette harbor. On the sandy beach in Evanston, Populus balsamifera grows abundantly.

In many places in the Evanston-Winnetka area large spruces, firs and Norway pines have been introduced. One large hemlock (Tsuga canadensis) was found on the Glenwood bluff north of Elm Street, Winnetka. These species are not natural here, their ranges ending farther north.

West of the Rose Hill bar, between it and the swamp forest is an unforested area which is now occupied by the North Shore Drainage Channel. The natural vegetation has been almost entirely destroyed, but was probably similar to that of the swampy tracts west of the C. and N. W. Ry. in Rogers Park. East of the ridge is a similar but smaller and more irregular depression which continues itself in the "Campus Meadow" of Northwestern University and the unforested swale between Sheridan Road and Sherman Avenue, south of Colfax Street. This is a part of the old swamp mentioned by Miss Willard and Miss Childs.

## CONCLUSIONS

The distribution and character of the areas of the three different associations at the present time are such as to suggest that the original forest probably covered practically the whole of the region studied, with the exception of the depression west of the Calumet ridge and that between Sherman Avenue and Sheridan Road. The outline of this forest was probably irregular extending into the marshy tracts where the ground rose high enough for the forest trees to live.

This forest was not divided into distinct associations set off by definite lines from each other but was apparently composite, consisting of mesophytic forest on the upland with a gradual transition to the xerophytic forest on the ridges and the swamp forest on the lowland plain. The swamp forest itself was more or less heterogeneous, approaching the xerophytic type on the higher ground and maintaining an almost hydrophytic vegetation in the lower spots.

This transition probably was not only horizontal, but vertical as well, the intermediate areas representing a gradual succession toward the mesophytic oak-hickory association which is apparently the temporary climax of the Chicago Region.

## SUMMARY

A survey of the present forests of the Evanston-Winnetka region, which includes the ends of the Lake Chicago beaches, shows that these are three forest associations found: the mesophytic upland forest, the xerophytic sand ridge type and the morainic swamp forest.

These forest association types are not in distinct areas, but there is a gradual transition from one to another.

The location of the association is dependent on the character of the soil and the drainage, the mesophytic forest on rich well-drained soil, the xerophytic forest on sandy, with good drainage and the swamp forest on the poorly drained lowland clay. Where the water stands too long during the year, no forest is found.

Conclusions are drawn as to the probable extent of the original forest and it is suggested that the present associations on the plain represent a succession toward the mesophytic association now found only on the upland.

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# DISTRIBUTION OF OAKS ON THE LAKE CHICAGO BARS IN EVANSTON AND NEW TRIER TOWNSHIPS

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This study originated in a class exercise in Forest Ecology, largely on account of the abundant fruiting of the red-black oaks in the summer of 1919. Interest was aroused by the large number of ellipsoid acorns observed and it was decided to investigate the relative number of specimens of Q. ellipsoidalis in comparison with those of the other species found in this region. It was also decided to study the relative distribution of the ellipsoid

oak and if possible find some indication of its ecological characteristics. It might be mentioned in passing that Q. alba did not fruit at all this year, and Q. bicolor Willd. and Q. macrocarpa Michx, very sparingly if at all.

The region studied lies within the district surveyed by Miss Simmons and reported in this volume and the particular portion included in this study consists of about fifteen blocks in the northern part of the city of Evanston, containing the ends of the Tolleston and Calumet sand bar ridges just before they disappear owing to erosion by the lake. It was intended to include the Glenwood bar in this study, but it was found that the oaks had been almost entirely removed from it in this region. One small patch at the Gross Point Road and Dempster Street was surveyed and will be described later.

Owing to the time when the study was begun, the acorns had mostly fallen from the trees and consequently the identification of the trees had to be made by an inspection of the acorns as they lay on the ground. Because this region is entirely built up, the acorns in many cases had been removed by raking of lawns, but even in those cases it was usually possible to find a few specimens lying in flower beds or in the spaces between the grass plots and pavements. Great care was observed in relating the acorns to the trees and in many cases it was possible to state only that there were ellipsoid trees in a certain spot without definitely indicating any individuals. Only specimens showing ellipsoid characters were preserved and it is possible that some were rejected which were really ellipsoid so that the numbers accepted represents a minimum rather than a maximum of those really present.

As the writer has not made much study of the ellipsoid oaks and as Trelease's article (Transactions Illinois Academy, Vol. XI.) is still in the printers' hands, the identification of the ellipsoid varieties was a difficult task. Professor Trelease very kindly assisted by identifying a few type speciments which were sent to him. As is known in regard to the ellipsoid oak, the acorns are extremely variable and the range of shape in those studied

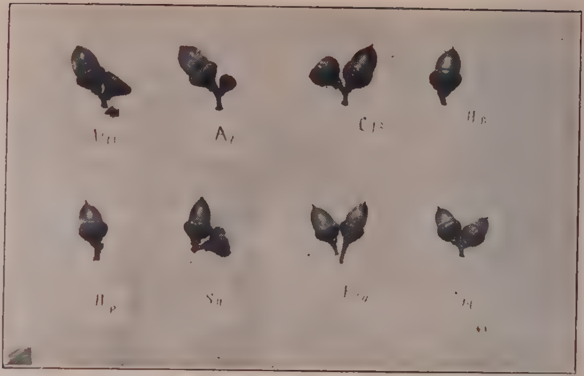

FIG. 1. Acorns of Q. ellipsoidalis showing variability in shape

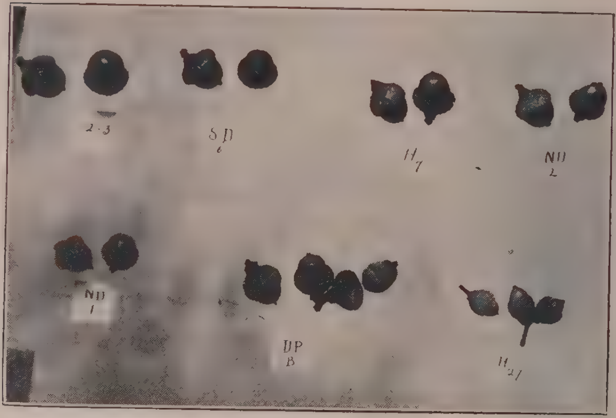


FIG. 2. Acorns of Q. ellipsoidalis var. depressa except DP-B which is Q. velutina and H-27 doubtful

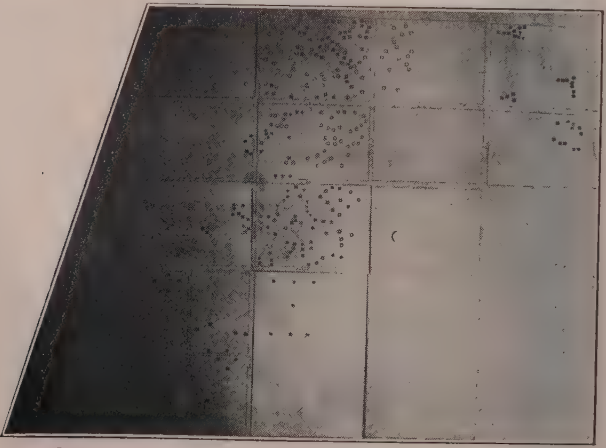

FIG. 3. Distribution of oaks in N. E. Evanston

is shown in Figure 1. In this the type form is that labelled Sh. and E 74. C 19 represents a reduced size due probably to lack of moisture and nutrition in extremely exposed conditions on the sandy ridges. D-64 and A-8 show a characteristic which has always been associated with the red oak (Quercus rubra); namely, the bulging of the acorn about in the middle of its length which led to the suspicion that D-64 might be a hybrid.

The variety depressa of Q. ellipsoidallis is shown in Figure 2. This variety shows characteristics suggesting the black oak (Quercus velutina) and some of the specimens found might be hybrids of these two species. In this figure D P a typical black oak is included for the sake of comparison while H-27, very much dwarfed in size, may be either a black or a peculiar ellipsoid.

The distribution of the oaks is shown by the map in Figure 3. The symbols representing the different trees were chosen with some care and experimentation to secure a symbol which would be sufficiently small to fit in with the scale of the map and yet be distinct to the eye. Even with the size adopted it has proved impossible to put one symbol for each tree observed, but instead an attempt has been made to let the number of symbols for each species be proportionate to the actual number of trees of that species found. It was found that only five or six symbols could be relied upon. On account of the small number of symbols available, it was impossible to represent even all the species concerned, to say nothing of the varieties of ellipsoid oak.

A study of the map shows first, the transition from ridge conditions to swamp conditions described by Miss Simmons. In this region no true ellipsoids were found and the oaks were identified only as swamp white (Quercus bicolor) or of the red-black type. The ellipsoid oaks were found chiefly on the Calumet bar, although some which are not recorded on the map were observed on the Tolleston bar on the campus of Northwestern University. This is left blank in the lower right hand corner of the map as there was not time to study it thoroughly before the acorns were removed either by

raking or by animals. In the patch of oaks studied on the Glenwood beach (not shown on the map) there were no true ellipsoids observed, but some that possibly were variety depressa.

On the Calumet beach two distributional characteristics of the ellipsoid can be observed: first, a tendency to be found mostly along the edges of the sand ridges and secondly, a tendency to segregate in small patches. The red oaks (Quercus rubra) are found on the whole in rather more mesophytic conditions, frequently occurring near the swamp white oaks and on the edges of the ridges nearest the intervening depressions. They reach their best development in the lowland forest bordering the flood plains of the Chicago and Desplaines Rivers. The white oaks when found are more usually along the tops of the ridges while the black oaks are the most xerophytic of all.

In conclusion, it may be stated, first, that the number of ellipsoids is much larger than was expected and it is probable that further surveys would show that in general Quercus ellipsoidallis is a much more numerous component of our oak forest than has been supposed.

It seems to occupy an intermediate position in regard to mesophytism between the black, white, and bur in the order named on the one hand, and the red and swamp white on the other.

For the reason stated above, this study must be regarded only as a preliminary survey and an intensive study under more exact conditions would give a more detailed knowledge of the distribution of these oaks, but probably would not alter the main conclusions arrived at.

The writer wishes to express his thanks to Professor William Trelease for his assistance in identifying the specimens and to Miss Catharine Blood and Miss Elizabeth Bryant who made the collections.

# TOPOGRAPHIC RELIEF AS A FACTOR IN PLANT SUCCESSION

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It is now generally accepted that there is a tendency for one plant community to pass to another in a somewhat definite series, from the pioneer vegetation of a region through successive phases to a community that is very decidedly richer and more mesophytic than any of the earlier vegetation. This series of changes has been designated plant succession, and has been extensively discussed by Cowles (1), Clements (2), and others. The final phase in the succession differs from the pioneer and intermediate ones, not only in its greater mesophytism, but also in its permanence and is termed the climax phase. Throughout the northeastern United States the climax plant community is a mesophytic forest in which deciduous trees predominate, and it has been assumed by many that all parts of the region will eventually be dominated by this, the richest type of vegetation that the climate is able to support. Progress towards this climax will vary much in the character of the different stages and in the rapidity with which they succeed one another, the differences being determined largely by the character of the soil, the development of its drainage, and the composition of adjacent vegetation. Man's activities in cutting and burning may cause temporary or even permanent halting or retrogression, but otherwise the progress will be steadily towards the climax even although the movement be imperceptibly slow.

While many ecologists have regarded the climax vegetation as limited by the climate only, others have seen in soil a limiting factor and recognized the establishment of permanent plant communities of distinct character due to the conditions of the soil. These communities would be called "edaphic climax communities," and they would be less mesophytic than the climatic climax of the region. Such communities have also been termed "temporary climax communities" by those who believe that they will eventually pass to the climatic climax, al-

though the steps in the succession may be almost infinitely slow.

Among the most striking examples of edaphic or temporary climax communities are the pine barrens of New Jersey so well described by Taylor (3) and by Harshberger (4), and the similar forests of scrub pine in Michigan spoken of as "the plains" by Spalding (5) and others.

In New Jersey the area is within a region capable of supporting a highly mesophytic forest in which chestnut, beech, maple and certain oaks are conspicuous. Further, the sandy plains have been continuously out of water for long ages, and are occupied by a plant community that gives evidence of being an "old climax condition infinitely more ancient than anything in the surrounding area"; nevertheless this vegetation is far below the climax of the region in mesophytism and in comparison with it is to be classed as a primitive community.

The vegetation of the sand plains of Michigan is similar to that of New Jersey. The principal tree of the former, *Pinus Banksiana,* closely resembles in habit and ecological relations the *P. rigida* which dominates the latter, while the associated forms in each instance are decidedly xerophytic, and very similar both floristically and ecologically as may be seen by comparing the descriptions of Taylor (3) and Gates (6). The Michigan "pine barrens" are in a region where the climax forest is characterized by the dominance of beech, maple and hemlock.

Many different causes have been given for the permanency of this primitive type of forest over the Michigan sand plains, but such attempted explanations have usually emphasized the character of the soil, its lack of fertility, its poor water supply, and its deficiency in humus or in essential mineral constituents. Harper (7) asserts with some plausibility that the difficulty is that the sandy soils leach freely and hence prevent the accumulation of any considerable amount of plant food material. Whatever may be the cause, the fact of the

apparent permanency of a primitive type of forest within a region of a mesophytic climax seems established beyond question, and also the further fact that this scrub pine forest is in both Michigan and New Jersey associated with a soil of almost pure sand and a topography of low relief.

In Michigan there exist other areas of sandy soil exhibiting quite different conditions of forest development. These are to be found more particularly along the western shore of the lower peninsula in the form of sand-dune areas of varied extent. The soil does not seem to be essentially different than that of the sand plains some miles farther inland, in fact, if there is a difference it seems to lie in the direction of the dunes having more nearly absolutely pure sand, free from any other soil whatever, than the sandy plains. The latter have frequently some small admixture of loam or similar fine material. But while the soil is similar the same cannot be said of the vegetation for while primitive stages closely resembling those of the sand plains are evident in portions of the forest cover of the dunes more particularly in newly formed areas, much of the older portions are covered by the climax forest of the region. Such a forest has been described by Waterman (8) in the Frankfort region, and it has also been seen by the writer at many different points, extending from Sawyer, at the south end of Lake Michigan to Bay View, Fox and Beaver Islands well to the north. This climax forest, although developed upon pure sand, differs very slightly from that upon other soils in the region the dominating trees being beech, maple and hemlock.

It is true that some dune areas such as those covering a portion of the Big Sable Point area, near Ludington, seem to have remained for a very long time with a very primitive vegetation cover, but adjacent portions of the same area are in climax forest.

What has caused this great difference in the rate of succession in these sand areas? In the opinion of the writer the differences in the topography relief have played an important part. It is a fact established by

frequent observation that in sand areas where dune building has been extensive and dunes of considerable height have developed there occur sheltered depressions where mesophytic vegetation soon becomes established on account of the lower evaporating power of the air and the consequent increased accumulation of humus. Such islands or centers of mesophytism are too well known and their occurrence will be too readily admitted to require further demonstration, but their importance as centers from which mesophytism spreads to surrounding territory has not been sufficiently recognized. From such centers go the seeds or other organs of dissemination to the fringe within shelter of the central forest association, and so completely is the spreading of the members of the climax forest accomplished that soon the very tops of the higher dunes are covered with beech and maple while adjacent plains remain in xerophytic scrub pine.

The successional stages may include as in southern Michigan, a pioneer pine forest with an evergreen undergrowth of *Juniperus, Arctostaphylos, Pyrola, Linnaea* and associated forms, a succeeding xero-mesophytic oak forest dominated by *Quercus velutina* and becoming gradually more mesophytic as indicated by the invasion of *Q. alba* and *Q. rubra*, and this in turn gradually giving way before the encroachment of *Tsuga canadensis, Acer saccharum*, and *Fagus grandifolia*. Farther to the north the oaks disappear but the maple and hemlock remain with equally mesophytic undergrowth, and such tree associates as the white spruce, *Picea canadensis*, and the yellow birch, *Betula lutea*. Whatever may be the modifications in the rate and phases of the succession the ultimate and comparatively speedy arrival at a rich mesophytic climax forest association leads to the conclusion that the high relief of sand dunes affords an excellent demonstration of the importance of mesophytic centers, developed in protected local areas, in inducing and hastening the development of the more advanced stages in plant succession.

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# NOTES ON THE DISTRIBUTION OF THE OAKS AND THE BUCKEYE IN LA SALLE COUNTY, ILLINOIS

Geo. D. Fuller, University of Chicago

While engaged in an ecological forest survey of a portion of La Salle County, the results of which have already been reported,[1] the writer's attention was attracted by the somewhat peculiar distribution of certain trees, principally species of Quercus and Aesculus. The survey covers the larger proportion of that part of the county lying north of the Illinois River and the parts of La Salle and Peru townships south of that stream. The exact limits of the survey are indicated in the maps accom-

[1] Fuller, Geo. D., and Strausbaugh, P. D., The forests of La Salle County, Ill., Trans. Ill. Acad. Sci. 12: 1920.

panying the report just cited and the following notes on species distribution may be regarded as an appendix to that paper. Collections were made of certain of the oaks of which 8 species were found within the county. Special attention was given to the black oaks *Quercus velutina* and *Q. ellipsoidalis* and to one or two other species of rare occurrence. Material of these collections, bearing the collection numbers, have been placed in the herbaria of the University of Illinois, at Urbana and of the Field Museum of Chicago. No attempt at completeness has been made but it is thought that the following notes may be worthy of record.

1. *Quercus alba* L., white oak. This species is found in all the upland forests often forming 40 to 60 per cent of thé present stand.

2. *Q.macrocarpa Michx.*, bur oak. This oak also occurs throughout the county in the upland forests and is rather abundant upon the drier flood plains. A form collected in Earl Township, Sect. 17, No. 1128, showed a particularly small acorn, another collection, No. 1117, was made in Earl Township, Sect. 8, and a third, No. 1109, in La Salle Township, Sect. 25, upon a stream terrace.

3. *Q. bicolor Willd.*, swamp white oak. A single small stand of this species was found in Dimmick Township, Sect. 3, upon the flood plain of Vermilion Creek, Collection No. 1162.

4. *Q. Muhlenbergii* Engelm., yellow chestnut oak. The species is not abundant, forming a very small per cent of the stand and is apparently confined to the uplands near the Illinois and Fox Rivers. Collections: Peru Township, Sect. 19, No. 1133; La Salle Township, Sect. 11, No. 1134 and Dayton Township, Sect. 4, No. 1160.

5. *Q. rubra* L., red oak. Found throughout the county upon somewhat sheltered slopes, in ravines and upon the uplands most advanced in mesophytism.

6. *Q. velutina* Lam., black oak. This is the principal element forming the more xerophytic upland forests. It is abundant in Starved Rock Park and was collected in the following townships: Earl, No. 1126, and Serena

No. 1161. A specimen, No. 1112, collected in Troy Grove, Sect. 35, may be hybrid with *Q. ellipsoidalis.*

In this and the following species the writer is glad to acknowledge the assistance of Professor William Trelease in the identification of the collections.

7. *Q. ellipsoidalis* Hill, Hill's oak or Hill's black oak. This species is often confounded with the preceding from which it is not always easily distinguishable. Several varieties have been recognized by Trelease. It seems to be more plentiful in the northern half of the county and was collected in the following townships: Troy Grove, Sects. 11 and 18, Nos. 1101, 1106 and 1107; Earl, Sect. 8 and 17, Nos. 1120 and 1129, the latter being apparently var. *intermedia;* Utica, Sect. 7, No. 1155, and Dayton, Sect. 4, No. 1158.

8. *Q.imbricaria* Michx., shingle oak. Found occasionally along stream bluffs. Usually small in size. Collections: La Salle Township, Sect. 13, No. 1148, and Dayton Township, Sect. 4, No. 1159.

*Aesculus glabra* Willd., fetid buckeye. A single specimen was found in Troy Grove Township, No. 1110, a few scattering specimens near the town of Peru, but only south of the Illinois River did it become rather frequent in its occurrence.

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## A COMPARISON OF SOIL TEMPERATURES IN UPLAND AND BOTTOMLAND FORESTS

W. B. McDougall, University of Illinois

In connection with some ecological studies that were being made on the vegetation of Vermilion County, Illinois, during the summer of 1918, a series of measurements of soil temperatures was undertaken for the purpose of comparing habitat conditions in upland and bottomland forests. Unforeseen events prevented this from being carried out on as extensive a scale as had been intended but it is believed that the few readings obtained are worth recording in view of the fact that available data on the subject are very meager.

The measurements were made at two stations located east of the Middle Fork of the Vermilion River and between the C. C. C. & St. L. and I. T. S. railroads. The river at this place is bordered on the east by a strip of typical bottomland forest 300 to 500 feet wide. The dominant trees here are American elm *(Ulmus americana)*, sycamore (*Platanus occidentalis*) and soft maple *(Acer saccharinum)*. Common secondary trees are the hackberry *(Celtis occidentalis)*, box elder *(Acer negundo)*, *green ash (Fraxinus pennsylvanica var. lanceolata)*, bur oak *(Quercus macrocarpa)*, walnut *(Juglans nigra)*, honey locust *(Gleditsia triacanthos)*, black maple (*Acer saccharum var. nigrum*) and cottonwood (*Populus deltoides*). The dominant species of the herbaceous layer are the wood nettle (*Laportea canadensis*) and the pale touch-me-not (*Impatiens palida*) both of which grow very vigorously, reaching heights of four feet or more, and often occupying the soil over considerable areas to the almost total exclusion of other herbaceous plants.

At the eastern edge of the bottomland forest the land rises by a steep slope to the upland plain about 70 feet above. The slope itself is clothed with a transitional mixed hillside forest in which the dominant trees vary from those characteristic of the bottomland forest at the base, through the most mesophytic species of the region, namely hard maple *(Acer saccharum)*, red oak *(Quercus rubra)* and beech *(Fagus grandifolia)* which are found part way up the slope, to the more xerophytic species of upland forest types such as the white and black oaks *(Quercus alba* and *Q. velutina)*, and the shag-bark and pig-nut hickories *(Carya ovata* and *C. cordiformis)*. At the top and adjacent to the slope the soil was formerly occupied by the ordinary oak-hickory mesoxerophytic association. Most of this adjacent land, however, has been cleared and is under cultivation.

The upland station selected for making soil temperature readings was just at the top of the slope where the land begins slanting to the west. The particular place chosen was near a cluster of raspberry bushes where the other undergrowth was also abundant and the instru-

ments were therefore practically hidden from view. This was necessary to prevent their being tampered with by hunters or other pedestrians. The bottomland station chosen was about 50 feet from the bottom of the slope in the middle of a dense patch of wood nettle and touch-me-not.

The thermometers used were of the type sold by Henry J. Green of Brooklyn, N. Y. Each thermometer is enclosed in a wooden case and has an exposed scale about eleven inches long. Two thermometers were used at each station; one for taking the temperature at a depth of three inches and the other at a depth of twelve inches. These are the depths at which series of readings have been taken for the Committee on Soil Temperature of the Ecological Society of America by a number of collaborators in different parts of the United States. The thermometers were set on June 21, 1918, and left undisturbed until September 25, 1918. Readings were made on both of these dates and on seven intervening dates. The readings were in every case made as near to 12 o'clock noon as possible and always in the same order, the thermometers at the upland station being read first and those at the bottomland station about five minutes later. Tables I and II give the results of these readings in degrees Fahrenheit.

TABLE I

Soil temperatures at depth of three inches

| Date | Upland | Bottomland | Difference |
|---|---|---|---|
| June 21 | 67.0 | 64.0 | 3.0 |
| June 24 | 62.5 | 59.0 | 3.5 |
| July 5 | 69.0 | 66.2 | 2.8 |
| July 6 | 68.0 | 65.5 | 2.5 |
| July 12 | 62.7 | 61.2 | 1.5 |
| July 13 | 63.0 | 61.2 | 1.8 |
| Aug. 12 | 75.5 | 72.2 | 3.3 |
| Aug. 27 | 72.0 | 70.0 | 2.0 |
| Sept. 25 | 55.0 | 53.2 | 1.8 |
| Average | 66.0 | 63.6 | 2.4 |

TABLE II

Soil temperatures at depth of twelve inches.

| Date | Upland | Bottomland | Difference |
|---|---|---|---|
| June 21 | 65.0 | 62.4 | 2.6 |
| June 24 | 63.2 | 59.8 | 3.4 |
| July 5 | 67.4 | 64.0 | 3.4 |
| July 6 | 66.5 | 62.2 | 4.3 |
| July 12 | 61.5 | 60.2 | 1.3 |
| July 13 | 62.5 | 60.9 | 1.6 |
| Aug. 12 | 73.0 | 70.2 | 2.8 |
| Aug. 27 | 69.5 | 68.3 | 1.2 |
| Sept. 25 | 55.8 | 54.0 | 1.8 |
| Average | 64.9 | 62.4 | 2.5 |

An inspection of these tables shows that the soil in the bottomland forest is constantly colder than that in the upland forest, the average difference at three inches being 2.4 degrees and at twelve inches 2.5 degrees. The greatest difference found at three inches was 3.5 degrees on June twenty-fourth and at twelve inches the greatest difference was 4.3 degrees on July sixth. The smallest difference recorded at three inches was 1.5 degrees on July twelfth and at twelve inches 1.2 degrees on August twenty-seventh. These various facts are shown graphically by figures 1 and 2.

Measurements of air temperature were made on only three different days as shown in table III.

TABLE III

Air temperatures in degrees Fahrenheit

| Date | Upland | Bottomland | Difference |
|---|---|---|---|
| July 6 | 80.5 | 74.6 | 5.9 |
| July 12 | 70.8 | 67.2 | 3.6 |
| Sept. 25 | 64.0 | 61.0 | 3.0 |
| Average | 71.7 | 67.6 | 4.1 |

This table indicates that there is an even greater difference in air temperatures than in soil temperatures in upland and lowland forests, the average difference in air temperature for the three readings taken being 4.1 degrees.

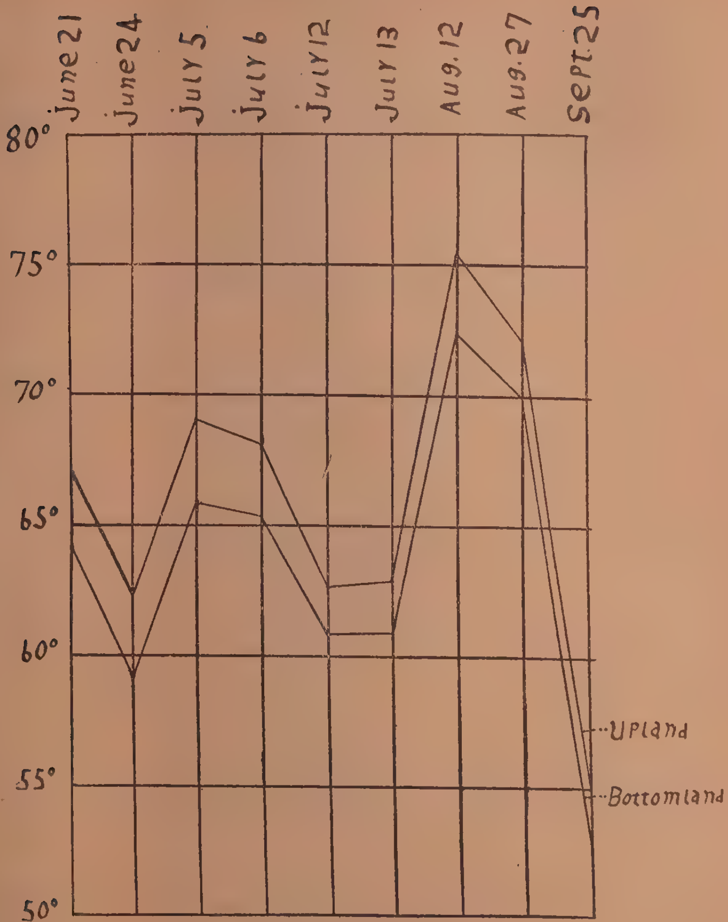


Fig. 1. Soil temperatures at 3 inches

These temperature differences at first thought do not seem very great but the difference in the number of heat units received by the upland and bottomland plants during any time unit must be multiplied by the number of time units in the whole growing season. When we remember that a decrease in the average annual temperature of North America of only four degrees would probably be enough to bring about another glacial period we

realize that the actual amount of heat received during a season by bottomland plants is very much less than that received by upland plants and may be an extremely important environmental factor.

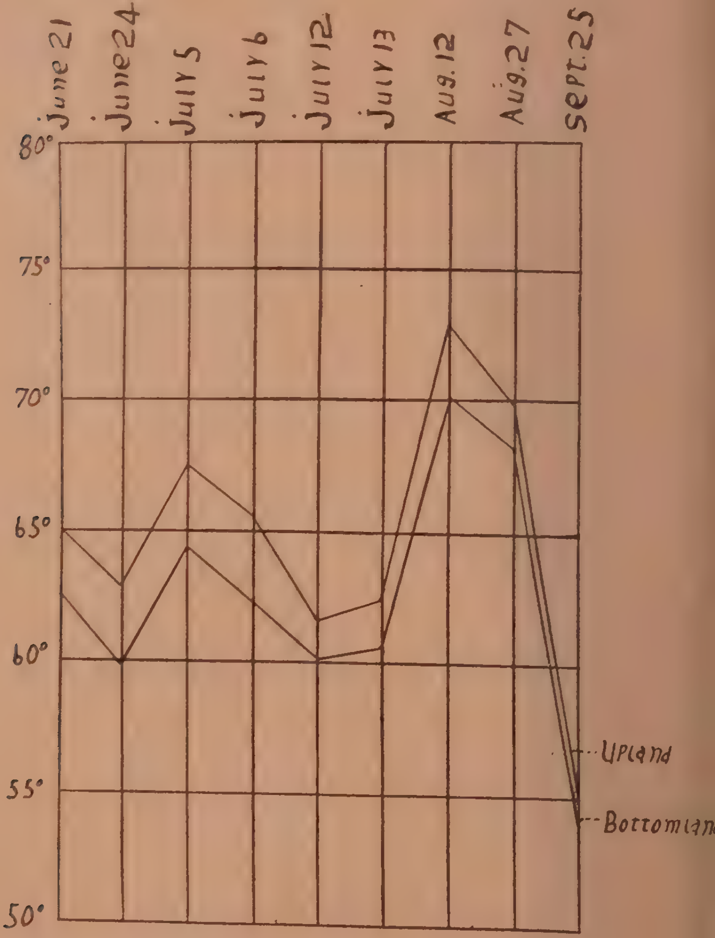


Fig. II. Soil temperatures at 12 inches

# Papers on Zoology

# PHYSIOLOGICAL LIFE HISTORIES OF TERRESTRIAL ANIMALS AND MODERN METHODS OF REPRESENTING CLIMATE[1]

BY VICTOR E. SHELFORD, UNIVERSITY OF ILLINOIS

## I. INTRODUCTION

Modern ecology had its beginning with the publication of Warming's work on the sand dunes of Denmark. He discovered in these studies that it is possible to classify and arrange the various plant communities which he found there in a natural order. This is the distinctive thing about modern ecology; the ecology of communities of organisms is known as synecology. It enables us in our studies of the peculiarities of various domestic species and pest species to refer them back to the original conditions in which they were found. In other words, it has made it possible for us to locate organisms in their natural environments correctly and in a manner which other trained ecologists can understand. From time to time one hears biologists, particularly zoologists, asking why the term ecology is used and what modern ecology is all about, anyway, but these people have merely neglected to become acquainted with its distinctive features which are synecological or have to do with the ecology of communities.

Perhaps the second distinctive feature of modern ecology lies in the attempt of ecologists to study what are known as physiological life-histories of organisms. By this is meant all physiological changes during the life cycle or during an annual cycle in the case of animals with several generations, and the relations of these physiological changes to external conditions. Ganong (1917) expressed the view that if we could learn the physiological life-history of the plant we would be well on the road to the solution of the ecological problem.

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[1] Contribution from the Illinois Natural History Survey and from the Department of Zoology of the University of Illinois No. 161. For details regarding the work on insect pests referred to herein see Bulletin of the Illinois Natural History Survey. This paper is the substance of an address before the American Society of Zoologists at its St. Louis meeting Dec. 31, 1919 and the Illinois chapter of Sigma Xi, Jan. 11, 1920, and an address before the meeting of the Illinois Academy of Sciences at Danville, Feb. 21, 1920.

## II. EXAMPLES OF PHYSIOLOGICAL LIFE-HISTORIES

Some of the best known examples of physiological life-histories are suggested by some of the insects. One of the tiger beetles (*Cicindela hirticollis* Say) deposits eggs in June; these hatch in the sandy soil in which they are laid, feed on ants and other insects, molting once or twice during the summer. When the cold weather begins they close their burrows and remain below ground during the winter. They begin feeding again early in the spring, pass to the pupa stage, and emerge as adults in July. After feeding for a few days the adults burrow into the sand and remain until the following June when they come out of hibernation, deposit their eggs and remain in their habitats in some numbers so that in the ordinary summer, one is able to collect these old individuals mixed with the new freshly emerged ones of the next generation. Thus in this species we have two years between generations and some special conditions apparently necessary both in the larva and in the adult, before they will proceed with development at the time of the usual hibernation period.

The codlin moth of the apple passes the winter in the larval stage, pupates after a few warm days in spring. The pupae emerge as adult moths about the time that the apple trees have begun to leaf out. They deposit eggs which on hatching into small larvae provide the so-called worms which are familiar in wormy apples. The small larvae enter the young fruits and after feeding for a time reach the fully grown condition, make their way out, down to the tree trunk where they spin a cocoon, pupate, and produce a moth which again lays eggs for the second generation. Under certain weather conditions a third generation is produced late in the summer, but under certain other weather conditions no larvae of this second generation of moths will proceed with development until after some special conditions of temperature and moisture have been imposed upon them. Thus we see the physiological life-history of the codlin moth varies with weather conditions and presents some special

problems, though perhaps problems of a kind which are common to most animals.

### III. THE EFFECT OF CONDITIONS ON PHYSIOLOGICAL LIFE-HISTORIES

From the standpoint of insect pests such as the codlin moth it is important to know how external conditions effect the rate of development, fecundity and length of life of the individual. It has long been known that temperature has an important effect. De Candolle, the noted Swiss botanist, stated in 1830 that the time to maturity of wheat, for example, differs with the mean temperature above 6°C. So that the "total degree days" or the number of degrees above 6°C multiplied by the number of days has a constant value. When De Candolle stated this he also stated the time temperature curve for the development of a plant is an equilateral hyperbola, the reciprocal of which is a straight line crossing the axis of temperatures at the temperature at which development does not take place but immediately above which development begins to take place. In the ninety years that have elapsed since this discovery, this principle has been discovered repeatedly and announced as new and original. (See Figure 1). It was not until 1914 that the Danish physiologist, Krogh, working upon the frog's egg discovered that this law holds good only within a limited range of temperature. He published a list of the various species which had been studied and gave the limits within which the law could be expected to hold. It will be seen from Figure 1, particularly from the reciprocal curve, that development is a little too rapid at the lowest temperatures and considerably too slow at the highest temperatures to conform strictly to the equilateral hyperbola and a fixed total temperature for completion of development. Nevertheless this method constitutes a valuable guide in many kinds of study but it has been found in the course of studies carried out on the chinch bug and codlin moth in the University of Illinois Vivarium under the auspices of the Natural History Survey that many factors other than temperature influence

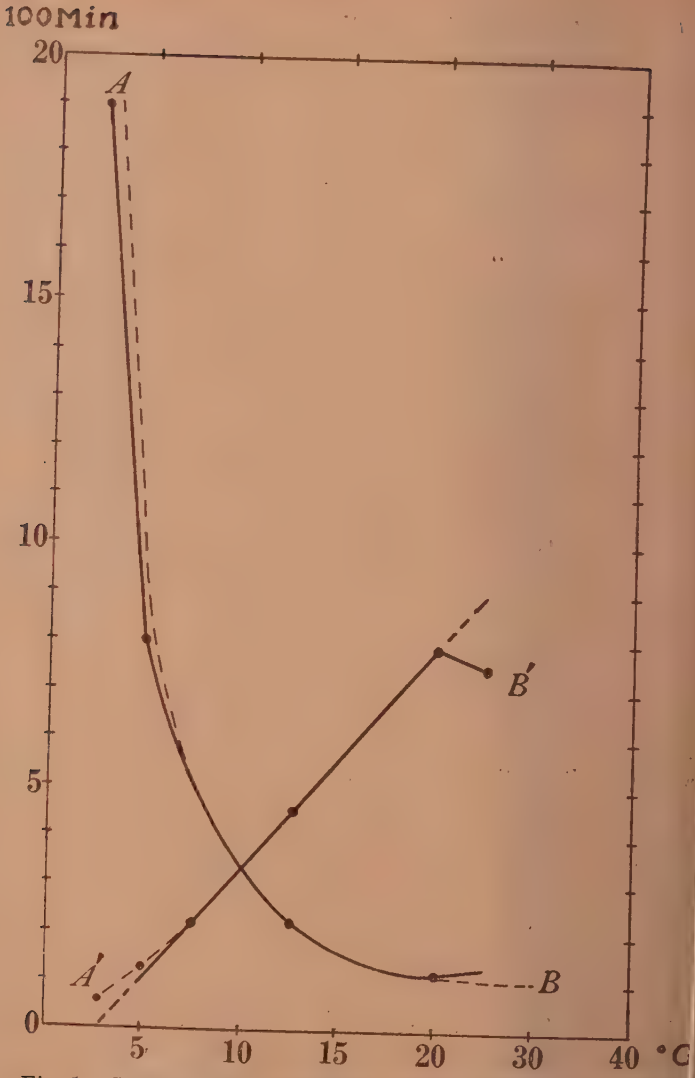



Fig. 1. Curves of the development of the frog's egg at differen temperatures. The curve AB is the time temperature curve for de velopment of the first cleavage plane. The curve A'B' is the reciproca of the time temperature curve, i. e. the $\frac{1}{\text{Time in minutes}}$ plotted o the temperatures in question. The distance above the axis of temper tures represents relative velocity of development.

the length of stages and the rate of development. Humidity is one of these; light, variability of temperature, air movement and rate of evaporation are others. On account of these complications it is necessary to express rate of development in more than one dimension. In 1910, Ball writing in the Cairo Scientific Journal used diagrams laid out on section paper in which he represented temperatures on the scale at the left and the humidity on the horizontal scale at the top. He plotted as points on this chart temperature and humidity for each month in the year for various oases in the Sahara and then connected the points so plotted with straight lines. (See Figure 2). Later Griffith Taylor (1914) of Australia followed this same plan plotting the optimum humidity and temperature for man on such a chart accompanied by various similar plots for cities of the various parts of the world. He used wet bulb temperatures which rendered his work not strictly comparable with that of others. In 1916 Pierce applied this same principle to the Mexican Boll Weevil, but since he followed the usual custom of the Bureau of Entomology in not citing any authorities, it is not possible to tell whether he originated the idea independently also.

In the case of humidity and temperature in our work on the codlin moth we have found it possible to plot the length of the pupal period, the pupal mortality, and the failure to pupate in this fashion with advantageous results. The pupal mortality is indicated at certain temperatures and humidities in figure 3. Another type of diagram is being prepared which we believe will prove to be quite helpful in making predictions regarding the time of appearance of the adult codlin moth. On this diagram we are plotting for each temperature the per cent deviation in the length of the pupal period due to humidity, but the work is not complete. On a diagram of this kind it is possible to plot also the march of temperature and humidity for each day and thus determine whether the humidities will have a marked effect on rate of development or only a slight effect. Probably such diagrams could be made for temperature and light, tem-

perature and evaporation, and temperature and air move-
ment.

Light influences the length of the codlin moth pupa
stages as much as ten per cent. Evaporation difference
may cause the length of the pupal stage to be doublec
under certain conditions and the effects of air movemen
are often similar. Variability of temperature shorten

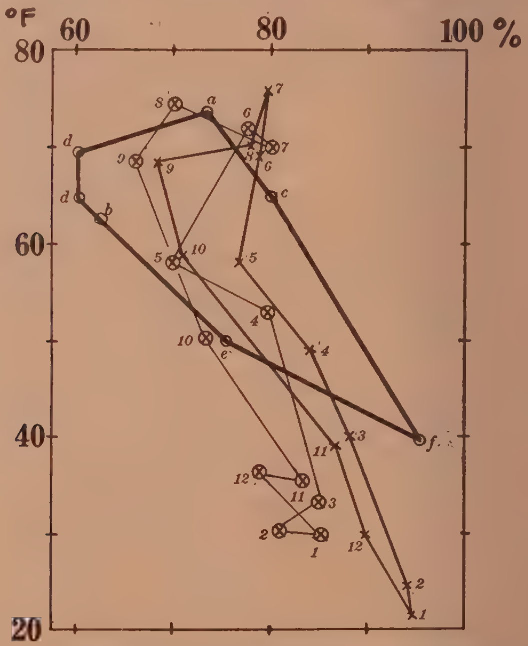



Fig. 2. A climograph or temperature-humidity graph for ma
and for two years at Urbana, Ill. Horizontal distance represents hu-
midity; vertical temperature in Fahrenheit. The heavy curve wit
lettered angles connects the following: a, temperature and humidit
comfortable for men lightly clothed and making no exertion; b, th
same when exercising; c, the lowest death rate; d, high efficiency fo
factory workers in summer; e, the same in spring and fall; f, the sam
in winter. The light curve with crosses inside of circles at the angle
and numbers adjacent connects the points representing the mea
monthly temperature and humidity at Urbana, Ill., for the year 1897 i
which the chinch bugs did damage at Urbana and in which the death
rate was high in Chicago. The numbers refer to months. The simila
curve with crosses at the angles is for the year 1891 in which ther
was no chinch bug damage in Champaign county and the death-rat
was low in Chicago.

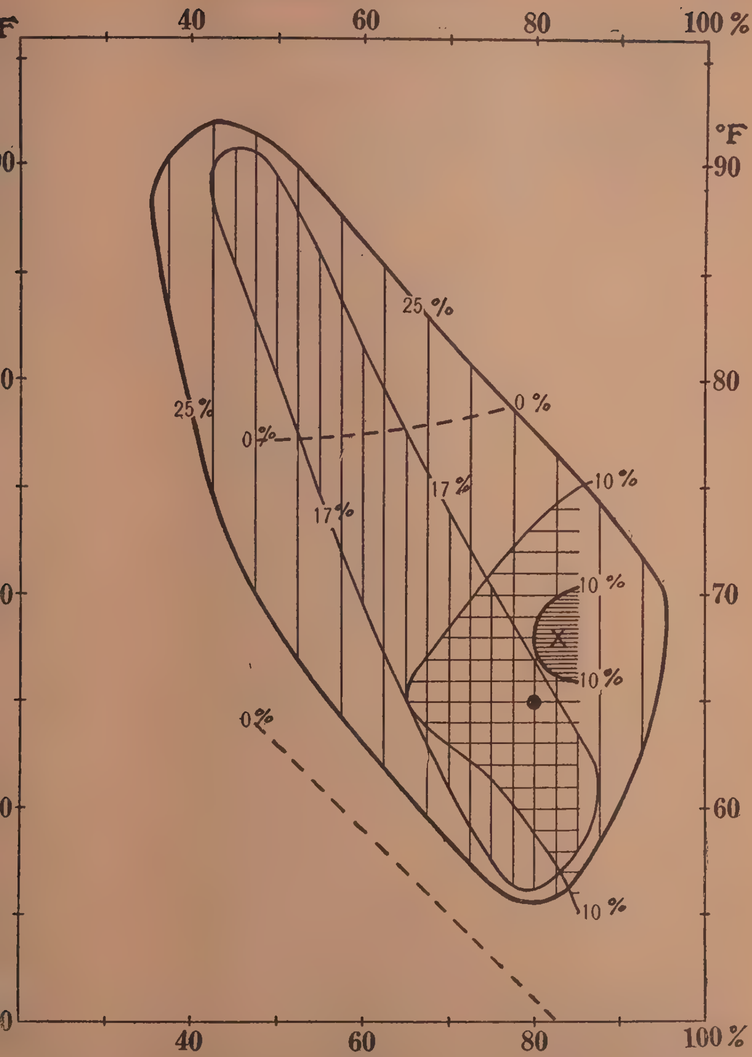
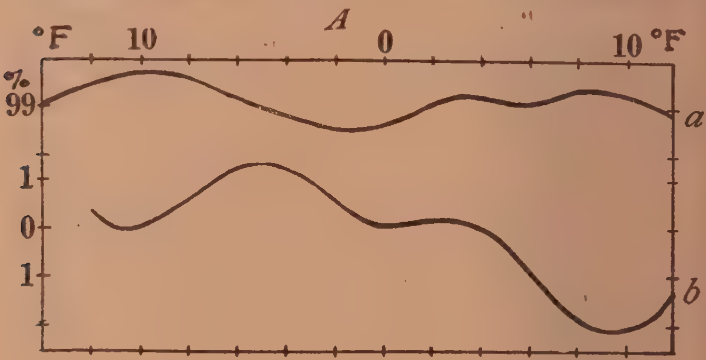



Fig. 3. Climograph for the death-rate of man shown with horizontal rulings. The broken lines (0%) are drawn along the combined temperature and humidty conditions under which the death-rate is normal and hence the deviation from normal 0%; for the white man. The curve bounding the sparsely ruled area and labeled 10% passes through the temperature and humidity conditions in which the death-rate is 10% below normal for the white man; the lowest death-rate 65°F. and 80 per cent humidity is shown by a black dot. The closely ruled area shows a death rate 10% less than normal for the negro and the x is placed near its center on a humidity of 81 per cent and a temperature of 68°F. (after Huntington). The vertically ruled areas indicate the deaths (% individuals) of codlin moth pupae under experimental conditions.

the length of the stages ten or more per cent as compared with the constant temperature of the same numerical value (see Figure 4 B). Another very interesting result of the experimental work is the demonstration of the fact that the so-called threshold of development for temperature which is the temperature just above which development begins, differs under wet and dry conditions



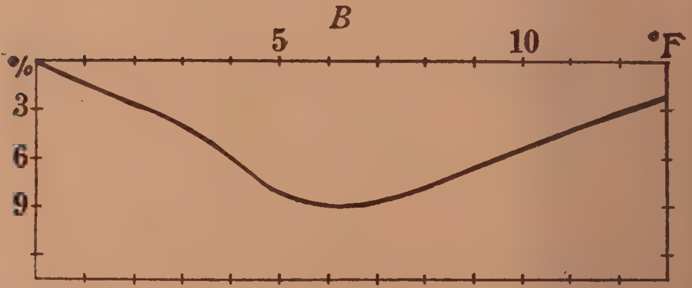




Fig. 4A and 4B. Shown the effects of variability on human efficiency and insect metabolism.

(a) Curve A shows the effect of changes of temperature on the efficiency of 300 men in a Connecticut factory. The center 0 indicates no change in temperature from the preceding day. At the right are shown rises of temperature and to the left fall in temperature in degrees. In general variability favors efficiency. Curve B shows the same for students but decrease in efficiency with rise in temperatures which exceed 5° are evident (after Huntington).

(b) Is a curve showing the effect on the length of the pupal stage of the codlin moth of a daily rise in temperature indicted by the scale. The vertical scale gives the per cent deviation from a constant temperature with the different amounts of increase.

and in different generations in the same year also in different years. The threshold of development for the egg as determined by Mr. Spooner is somewhat lower than that of the pupa, while the threshold of development temperature of the larva is perhaps still lower. These threshold values are calculated by the use of the equilateral hyperbola and its reciprocal as already described and of course the values are only approximate. Calculations of the threshold can usually be made whenever a change in the factor amounting to about 1/3 of the maximum daily range of that factor halves or doubles the length of the stage. Thus the ordinary range of temperature to which the codlin moth may be subjected is at most about 30°C, and lowering the temperature 10° usually nearly doubles the length of the stage. This ratio for temperature is known as the quotient for 10° or the $Q_{10}$. Likewise the total range of humidity to which the codlin moth may be subjected is almost 90 per cent and lowering the humidity 30 per cent under certain conditions will double the length of the stage and thus a humidity threshold may be calculated under these conditions. The total degree-days for the length of codlin moth stages differs greatly with humidity and other conditions so that the results of experiments do not coincide exactly with the outdoor variable temperature and humidity conditions.

Having noted the effects of various climatic factors on the codlin moth some comparison with man who has been particularly studied will be valuable. Turning to Figure 3 we note that the line representing a death-rate 10 per cent below normal passes through a considerable number of different temperatures and humidities just as does the minimum death-rate of the codlin moth pupae and that both are oblique in the same direction but that man being a warm blooded animal does not show as great a temperature range as does the cold blooded codlin moth. On the same figure we have drawn the 10 per cent below normal death-rate of negroes and the center of this area falls on temperature about 68°F. and humidity about 83, while

that of the white man lies at 65° and 80 per cent relative humidity.

These two points are significant first in that our rooms are all too warm and dry being at 70°F. and 30 per cent instead of 65°F and 80 per cent. The negro who came to America from moist tropical Africa differs from the white man who came from somewhat drier and much cooler western Europe.

Variability of temperature is stimulating to the codlin moth pupae (see Figure 4 B). The amount of respiratory diseases among children in school rooms with window ventilation and accordingly more variable temperatures is only about half as geat as with fan ventilation. Furthermore Figure 4 A is taken from the work of Mr. Huntington and shows that variable temperatures increase efficiency. The manual laborer's efficiency is increased either by a rise or fall from day to day. Efficiency of brainworkers, especially students, is increased by a fall of temperature from day to day and decreased by a rise in temperature from day to day. And it seems that we have done well to choose the time of year for their most important examinations when the temperature is rising from day to day, it apparently being our purpose to eliminate as many students as possible. It is altogether possible that our schools should begin in the middle of August and close considerably earlier than they do.

Huntington has made a careful study of death-rate in relation to climate and weather and has compared business, school attendance, etc., with health or the death-rate curve inverted. Figure 5, curves A and B, show this relation for the entire eastern United States for 1880-1910. The curves for Great Britian are similar. Curves B and C of Figure 5 show the death-rate in Chicago and damage by chinch bugs in Illinois. During the period from 1885 to 1895 the death-rate in Chicago rose high. These were troublous times with strikes, bloody anarchists, and Haymarket riots at the close of the eighties, due to the presence of a democratic president in Washington and certain wild-eyed agitators in Chicago,

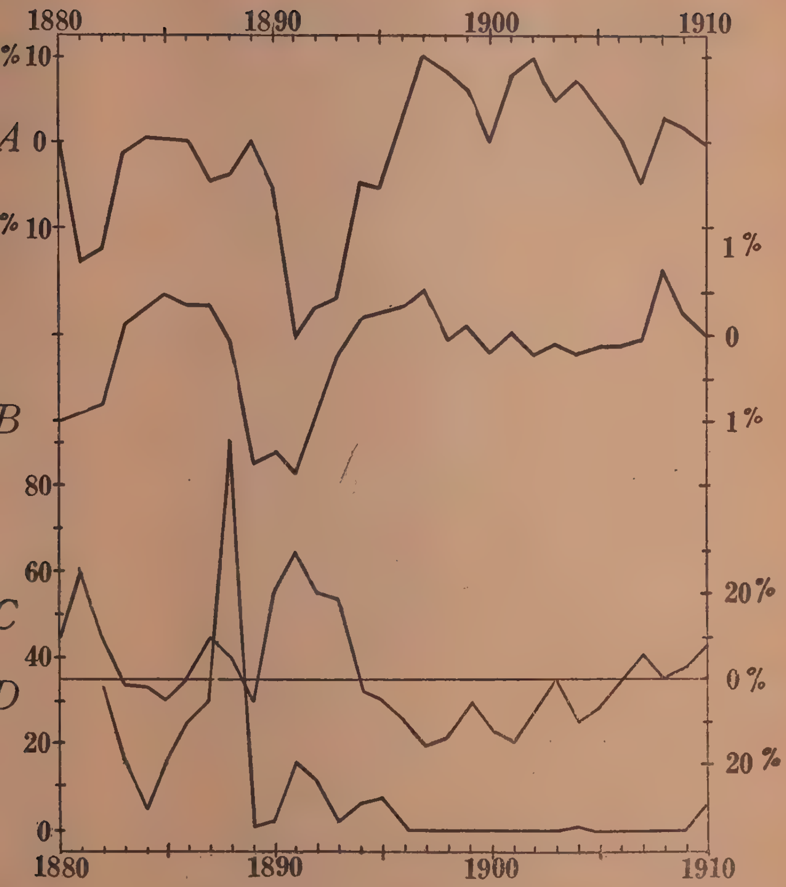



Fig. 5. Showing parallel curves for health, school attendance in eastern United States, death-rate in Chicago and chinch bug infestation in Illinois from 1880 to 1910. Curve A (scale at left) normal health of the general population is shown at 0% while bad health is indicated by per cent below and good health by per cent above. Curve B (scale at right) shows the parallel of school attendance to health. Curve C (scale at right) shows the death-rate in Chicago. Normal death-rate is indicated by zero per cent, high death-rate by per cent above and low death-rate by per cent below. Curve D (original; scale at left) shows relative chinch bug infestation in Illinois from records in the state entomologist's office. The records show three degrees of damage, slight, moderate and severe, by counties. Slight was given a value of 1, moderate 2, and severe 3; these figures were multiplied by the number of counties in each case, and then totaled, and then divided by two for convenience in plotting. There is a good correspondence between chinch bug damage and death-rate in Chicago; the entire state of Illinois would be better.

some of whom were hung and others who should have been! This was followed in the early nineties by a rail strike, panics, etc., due to the same causes as the earlier troubles.

The politicians did not make use of the health and death-rate curves but no doubt would have tried to prove that health was affected by political parties. The probabilities are that these disturbances were due in part, perhaps the larger part to ill-health, brought on by unfavorable weather. A comparison with the chinch bug curve indicates that weather which is detrimental to man is favorable to chinch bugs. Thus we see that with long experience and careful records it may be possible to check and anticipate various pest conditions by comparison with human death-rate, and vice versa.

Another type of work which has been undertaken recently is the plotting of the relation between temperature and rainfall in localities where certain crops are especially grown as compared with localities where it is desired to determine possibilities. One of this type of diagrams shown in Figure 6 which compares a locality in the Illinois corn belt with tropical Australia to show the general method. It is one adopted by Griffith Taylor to represent the climate of tropical Australia and to determine whether or not various crops such as cotton, coffee, etc., could be grown there.

There are further matters of interest in connection with man and his activities with relation to temperature and rainfall which demand some comment. On the basis of his experiments which have already been referred to and the opinion of various scientists whom he consulted, Mr. Huntington has mapped the areas of most stimulating climate and has published maps of these areas. The moist deciduous forest climate of western Europe and eastern North America afford the variability and conditions necessary to high efficiency along with mean temperatures and humidites approaching the optimum for the white race, namely, 65°F. and 80 per cent relative humidity. These areas are also regarded as possessing the highest type of civilization. Mr. Griffith Taylor has

shown that the yellow race has successfully settled in tropical regions which have 50 inches of rainfall. He finds that north Australia possesses some area of this sort which is not suited for settlement for the white man and Australia has excluded the yellow race from that which Australia cannot itself make use of. From these brief remarks I hope that I have made clear what is very evident to me, namely, that in dealing with insect pests,

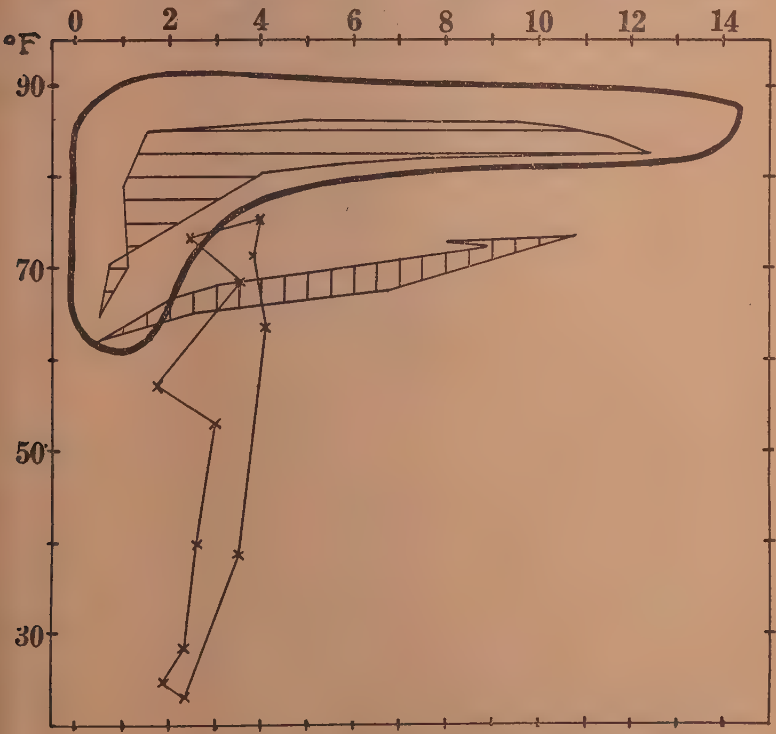



Fig. 6. Hythergraphs or rainfall-temperature charts of several localities. The figures at the top of the chart represent rainfall in inches. The vertical scale is degrees Fahrenheit. The heavy black line represents the rainfall temperature conditions in the Australian tropics. The horizontal rulings fill the space within the plot for Calcutta which is in the center of tropical cotton production; the vertical lines fill the space within the plot for Juiz, Brazil, the center of hill coffee production. One concludes that the Australian tropics are good for cotton but not for hill coffee. The curve with crosses at the angles is for Bloomington, Illinois.

dealing in crop production, in settling questions of such a delicate nature as the exclusion of certain races from certain regions, a knowledge of climatic data and particularly the effect of climatic factors on man and the organisms involved is of prime importance. A few years ago I received a letter from a federal official asking if the Ecological Society of America desired to have any particular kind of weather or climatic records taken, as they were planning a bureau of agricultural meteorology. It is my understanding that similar letters were written to various other biologists and agriculturists but that the weather bureau did not gain very much information as to what kind of records should be taken. This is the fault of biologists who have failed to conduct experiments on the effect of climatic factors on organisms. The character of the records to be made is determined by the

Fig. 7. The solid black shows the areas of most stimulating climate (after Huntington). The stippling shows the area in Asia and the Orient with 50 inches of rain per annum. The yellow race has colonized in the tropics only where there are 50 inches of rain. The heavy line indicates limits of colonization. They are excluded from these parts of Australia which are unfit for white men (after Taylor) but suitable for them.

effects of such climatic factors rather than any schemes that might look well on paper.

## ACKNOWLEDGMENTS AND BIBLIOGRAPHY

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# THE EFFECT OF SEWAGE AND OTHER POLLUTION ON ANIMAL LIFE OF RIVERS AND STREAMS[1]

Frank Collins Baker, University of Illinois

Stream pollution may be broadly divided into two main divisions: contamination by organic sewage from cities and towns and by chemical wastes from factories and mines. Both are inimical to life but the latter is especially fatal to animal life, causing wide stretches of otherwise fertile streams to become veritable deserts. Organic sewage, in a crude or highly concentrated form, is also very injurious, effectually eliminating most forms of life from the polluted body of water.

The importance and seriousness of the problem of stream pollution in its effect on the life of the rivers and streams into which the contaminating material is discharged has not, until very recently, been given the attention that the subject demands. The diminishing fish

[1] Contribution from the Museum of Natural History, University of Illinois, No. 11.

supply, and in many places the very objectionable physical character of the polluted waters, have caused the authorities of several states to pass laws governing the discharge of these wastes into streams and the establishment of penalties for disregarding these laws. New York and Massachusetts have led in the framing of these laws and other states are following the good example set by these two older commonwealths, where the conditions seem to have reached a maximum of harmfulness (see Ward, 1918, 1919).

During recent years stream pollution has enormously increased and the problems arising from this condition have been investigated by many biologists and sanitary engineers. The former have studied the problem from the viewpoint of its effect on the useful animal life, especially fishes and river mussels, and this phase probably bears as close a relation to human welfare as any other. Of course, from the standpoint of health, the pollution problem is of paramount importance because of its bearing on such diseases as typhoid fever which may be caused by a polluted water supply.

Perhaps the worst effect of chemical pollution is to be found in the streams of western Pennsylvania, where mine water heavily loaded with oil or acid water from coal mines is permitted to flow into the rivers and streams of this part of the state. Studies by Ortmann (1909) show that whole stretches of the Allegheny, Ohio, and Monongahela rivers have been made into deserts, as far as the animal life is concerned, by the large amount of poisonous substances discharged into these streams by the mines, oil industries, and chemical and other factories that border these rivers. In the Susquehanna River the same condition prevails in many places (Leighton, 1904). Such pollution causes a complete extermination of the fauna (and largely of the chlorophyl-bearing flora) and leaves the stream in such condition that restocking by either natural or artificial means is practically impossible, and if attempted is a waste of money.

Pollution by sewage, when the polluting material is of small percentage as compared with the pure water of

the stream (as 200 to 1), causes little inconvenience to the animal life and is doubtless of some benefit because of the additional food material that is added (Forbes and Richardson, 1919, p. 146). But the streams seldom remain long in this innoxious condition, the sewage becoming more and more concentrated and less diluted until the whole stream may be supersaturated with noxious substances, the amount of oxygen in saturation reduced, and the biota finally driven out or killed.

The Illinois River is one of the most striking examples of the effect of sewage pollution on the life of a stream. Under the direction of Dr. S. A. Forbes, studies of this river have been carried on for more than forty-two years (since 1877) and a mass of reliable data has been gathered. The opening of the Chicago drainage canal in 1890 produced most revolutionary changes in the life of the Illinois River by the discharge into it of the sewage of Chicago, as well as commercial wastes from this city and other places along the river (Forbes and Richardson, 1913, 1919). The effect of this sewage and other pollution has been to cause the animal life to be almost excluded from the upper parts of the river. That the polluted condition is creeping down stream is shown by comparisons of collections made in 1911 with those made in 1918. In the earlier years a foul water fungus disappeared from the river near Starved Rock; in 1918 it was found at Henry and Lacon, 35 and 41 miles farther down the river (Forbes and Richardson, 1919, p. 145). At the present time (1919) optimum conditions and a normal river fauna are not encountered until Peoria is reached, a distance of about 120 miles from the chief source of pollution at Lockport. Sewage from the towns and cities along the river also contribute to the general septic condition and retard the natural purification that occurs in all bodies of water.

A striking example of the deadly effect of sewage pollution on the mussel life of a stream is given by Wilson and Clark (1912, p. 34) in their study of the Kankakee River mussel fauna. "The DesPlaines River, which joins the Kankakee to form the Illinois River, is simply an

immense sewer bringing down the Chicago sewage. Both rivers, but especially the DesPlaines, are full of the characteristic algae and other vegetation which grow in such waters, and the combination of a copious vegetation with the sewage has effectually killed off all the mussels in the vicinity. Not a single living specimen could be found in either river; but there were hundreds of dead shells along the banks, most of these old and bleached, but still capable of identification''. This statement, of course, applies only to the lower part of the Kankakee River where the influence of the polluted DesPlaines has worked upstream for some distance. The Kankakee for the most part is a highly productive stream with a high rate of dissolved oxygen, in fact, the water is supersaturated with this life-giving element.

In the Maumee River (Wilson and Clark, 1912, pp. 26, 28) shell beds were found which had probably been killed by the refuse from gas works near the junction of the St. Marys and St. Joseph rivers. ''Spots of tar were found on dead mussels some distance below this point. The water was covered with an oily scum in places and a tarry odor was perceptible for several miles down the river''. Lower in the river the mussels were showing the effect of increased pollution of the stream by sewage.

Pollution is worst and usually most deadly to animal life during periods of low water and in winter when the amount of water in the stream is small and the decomposing organic material has less water to deprive of its dissolved oxygen. During times of floods the putrescent material is also carried down stream for many miles and cotaminates areas not previously affected.

While all clean-water forms of animal life are more or less affected by sewage pollution, the decomposition of the organic matter abstracting dissolved oxygen from the water and rendering it unsuitable for aquatic life, the fish, river mussels, and crayfish are particularly affected, most fish being especially sensitive to contaminated water. Some fish (as the brook silversides, *Labidesthes sicculus*) are notably sensitive, while others (as the black bullhead, *Ameiurus melas*) will endure water that

is badly polluted (Shelford, 1918, p. 27; Wells, 1918, pp. 562-567). Young fish are relatively more sensitive than adult fish. It is noteworthy that the more resistant species of fish are inhabitants of sluggish bodies of water, as ponds and shallow lakes, while the least resistant species live in running streams. It seems to be a question of the amount of oxygen necessary for the well being of the fish.

The ill effect of sewage pollution is most marked on the bottom of bodies of water, where a sludge is formed, often of great thickness (as much as ten feet in several cases), consisting of a mass of soft, black, sediment, with a high content of organic matter, in which only a few organisms, normally inhabitants of polluted streams, can live (e. g. septic Protozoa and Rotifera, foul-water algae, and slime-worms, Tubificidae). This effect on the bottom is perhaps the most serious phase of stream pollution because the septic condition of this area continues in operation long after the original source of contamination ceases to operate. This sludge formation renders the bottom unfit for clean-water life upon which many fish depend for food. The time necessary for the recovery of the normal biota of such a stream will in most cases be of long duration, and in the case of a stream polluted with wastes from mines and chemical manufacturies, there may never be a return to the original condition.

In New York State, the Genesee River, at Rochester, has afforded a striking example of stream pollution, of the effect of this pollution on certain animal life in the river, and of the return of this life when the amount of pollution had been largely reduced. This stream has been under observation by the writer for a period of twenty-seven years (1892 to 1919) and collections of the molluscan life have been made from time to time, both before the period of maximum pollution and since that time. The portion of the river studied lies below the lower falls north of Rochester, and about a quarter of a mile below the outfall of several large trunk sewers, the sewage being discharged into the stream in a crude condition. Refuse and other waste matter, both liquid and solid, also

enter the stream from gas works, tanneries, and manufacturing plants above the lower falls.

Collections made in 1892, before pollution became notably apparent, included nine species of gastropod mollusks, three being water breathers and six air breathers, These species were identified as:

*Musculium transversum*
*Musculium partumeium*
*Bythinia tentaculata*
*Planorbis trivolvis*
*Physa gyrina*
*Physa sayii*
*Physa heterostropha (=oneida)*
*Galba catascopium*
*Galba caperata*

Individuals were notably abundant, thickly covering the rocks and the shore. In 1897 it was observed that the sewage was increasing in volume and pollution was becoming more noticeable, the water looking like very heavy, greasy dish water. The river was visited and examined at short intervals from 1898 to 1919. Each year it was noted that pollution was rapidly increasing. In 1907, the water-breathing mollusks, *Musculium* and *Bythinia,* had succumbed and none could be found. The air-breathers, *Galba, Planorbis,* and *Physa,* still held out, though reduced in number of individuals. An examination made in 1910 failed to discover a single living mollusk of any species. Apparently the water had reached such a state of concentrated pollution that even the air-breathing mollusks, which normally come to the surface to take free air, could not adapt themselves to this most unfavorable environment and were either killed or compelled to migrate down the river to a point where pollution was less deadly. During the following years, 1910 to 1913, the river was visited but no mollusks were found.

During the summer of 1912, Mr. G. C. Whipple, professor of Sanitary Engineering in Harvard University, made a study of the effect of the sewage pollution on certain animal and vegetal life in the Genesee River (Fisher,

1913, pp. 179-200). This study was made when pollution was at its maximum and during the period when molluscan life had disappeared from the lower part of the river. The dissolved oxygen in the lower river, below the trunk line sewer, in July and August when the temperature was high and the water low, varied from 5 to 41 per cent of saturation. The water at the bottom of the river almost always contained less oxygen than that at the surface. On one day in August, the percentage of saturation in a distance of three miles did not exceed 5 per cent from the surface to the bottom of the stream, which has a depth of about twenty-six feet. The number of bacteria per cc. for this period was 1,650,000 near the source of pollution and but 67,000 near the mouth of the river where the influence of the pure water from Lake Ontario increased the amount of dissolved oxygen.

In 1917 a large part of the city sewage was diverted to a disposal plant situated near the shore of Lake Ontario. Here an average of 32 million gallons of sewage are treated daily and the treated sewage discharged into Lake Ontario in deep water at some distance from the shore. It is at once apparent that when this large amount of sewage was discharged into the Genesee River in a crude condition, it could not but render the water totally unfit for animal life and a menace even to the inhabitants who visited the beautiful parks bordering both sides of the lower Genesee River.

The result of the diminution in the amount of sewage discharged into this river has been that the molluscan fauna, as well as other forms of animal life, have returned and are rapidly taking possession of the favorable environments which were in use previous to the maximum period of pollution. Collections made in September, 1919, contained six species, two being water-breathers and four air-breathers:

| | |
|---|---|
| *Musculium transversum* | *Planorbis trivolvis* |
| *Bythinia tentaculata* | *Physa integra* |
| *Galba catascopium* | *Physa oneida* |

It will be noted that of the returned species, one is different *(P. integra)* while four are missing,*Galba caparta*, *Physa gyrina* and *P. sayii*, and *Musculium partumeium*. It frequently happens that when a fauna returns to a habitat from which it has previously been driven, it is made up of a different aggregation of species (See Ortmann, 1909, for additional notes on this subject).

In the case of the Genesee River we have a striking example of the history of a polluted stream and its effect on one group of the animal life. Previous to the stage of great pollution there is a varied fauna of mollusks very numerous in individuals. In the course of eleven years the gill-bearing species are forced out and after a lapse of fourteen years all molluscan life ceases to live in this part of the river. Seven years later the greater amount of sewage is diverted to another outlet. Two years after this change we find that the mullusks have returned in as great numbers as before the maximum stage of pollution. The significance of all this lies in the fact of the early return of this life, and strikingly indicates that streams may become restocked with life in a short period after pollution has ceased to be of an unfavorable character. At the present time the sturgeon, which formerly resorted to the river to feed and breed, and had been driven out by the polluted condition of the stream, has returned, which is another indication of improved conditions. It is quite probable that the large fall in the river, some 60 feet in height, has had a marked effect in the return of these favorable conditions.

A study of the Salt Fork of the Big Vermilion River, now in progress, indicates that all clean water life, including mussels and crayfishes, has been excluded from this stream for a distance of fourteen miles, and a normal fauna of these animals is not encountered until a distance of twenty miles has been traversed. The shallowness of this stream has evidently provided a sufficient supply of dissolved oxygen and it is apparent that in a deeper stream the ill effects of sewage pollution would be experienced for a much greater distance.

Wherever stream pollution occurs it is evident that the clean-water animals will sooner or later be driven out or killed. Such a condition seriously effects our food and game fishes, which form so large a part of the meat of our population, and the situation demands immediate attention and early remedy. It is a matter of great satisfaction to scientific men that the authorities are awakened to the seriousness of such conditions and that they are providing adequate remedies in many places.

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# SEXUAL DIMORPHISM IN THE ACANTHOCEPHALA[1]

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Frequently, animals differing widely in appearance belong to the same species. Polymorphism, as this condition is called, occurs in various groups throughout the animal kingdom and is especially prominent in insect states and in the colonies of some of the coelenterates, especially among the Siphonophora. Under these conditions individuals representing each of the different forms carry on restricted, specialized functions for the colony or state. The causes of such diversity of form within the members of the same species are not understood thoroughly. There are those who contend that polymorphism has arisen as a result of a division of labor among the individuals while others adhere just as strongly to the view that because the individuals are different they are thereby fitted for only one kind of special work and consequently each does the work for which bodily structure fits it. The type of bodily difference accompanying restricted function most frequently encountered in the animal kingdom is that associated with the differentiation of the sexes.

Sexual dimorphism, as somatic differences between males and females is termed, is of frequent occurrence throughout the animal series. However, most of the published accounts dealing with this phenomenon have been concerned with the most conspicuous instances such as those in which male and female differ so profoundly in superficial characters that they might well be taken as representatives of entirely distinct species. Technically, any somatic difference, however slight, which enables one to differentiate males from females without an examination of the gonads, may be considered as sexual dimorphism. In many species certain restricted organs or parts of the body, not directly associated with the reproductive process, display distinctive differences in the two

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[1] Contributions from the Zoological Laboratory of the University of Illinois, No. 162.

sexes. Such characters are termed secondary sexual characters.

Much of the literature concerned with the explanations of dimorphism has placed strong emphasis upon the role of sexual selection as the factor which has originated and emphasized the secondary sexual characters. Most of the popularly cited instances offer no fundamental difficulty for such a possible origin. The development of horns or other organs of offense or defense in the males of mammals would seem to give such individuals greater chance of perpetuating their kind than possessed by other individuals not having such special organs. Similarly, there does not seem to be any fundamental objection to the possibility that females among the birds might show preference for the more highly colored and ornamented males as mates though many authorities question any such show of preference on the part of the female. In all of the most readily available accounts sexual selection and natural selection have been almost exclusively advanced as basis for the explanation of dimorphism. In fact, P. C. Mitchell in the Encyclopaedia Britannica (Eleventh Edition, Vol. 24:748) definitely contends in his discussion of Sexual Dimorphism that Darwin's theory of sexual selection is the only comprehensive suggestion capable of explaining why some males and females differ and others resemble each other.

In species having no direct copulation and in all those having no mating of the sexes, obviously sexual selection cannot operate in the development of secondary sexual differences. Frequently ardent advocates of a theory have been so blinded by the implicit belief in the all potent powers of some particular explanation of given phenomena that they have been unable to conceive of the possibility that various factors may act simultaneously to attain the same or similar end results. This seems to have been the attitude of recent writers who have tried to explain all secondary sexual characters on the basis of natural and sexual selection. Charles Darwin, the founder of the theory of sexual selection, has well pointed out that his theory could not be the sole

explanation for the development of dimorphism among the lower sexual animals. In the Descent of Man (Chapter 9) he states that among the lower organisms "it is almost certain that these animals have too imperfect senses and much too low mental powers to appreciate each other's beauty or their attractions, or to feel rivalry." It becomes a matter of considerable interest, then, to examine some of the lower bisexual organisms in which mating does occur in order to see if it is possible to offer any explanation of the factors causing dimorphism under such conditions.

In the course of work upon the Acanthocephala, I have come across a number of instances of sexual dimorphism which, because of the conditions under which they occur, seem to offer some interesting obstacles to the operation of sexual selection or of natural selection in their development. Before discussing the specific instances, a few facts regarding these organisms should be enumerated. The Acanthocephala are worms of uncertain phylogenetic relationships which, through complete adaption to the parasitic habit, have arrived at a state where they no longer possess a free living stage at any point in their life cycle. In the reduction of organs characteristic of free life the Acanthocephala represent the extreme condition of complete absence of any structures for locomotion in any stage of their development, and total elimination of all special organs dealing with the processes of metabolism. Similarly there has been an entire loss of all organs of special sense. The whole central nervous system consists of a small mass of ganglion cells from which a few fibers are distributed to the body wall and to the muscles which control the operations of the proboscis and of the anterior region of the body. In spite of the fact that these organisms are reduced to essentially little more than a sac for containing the developing reproductive elements and a special organ, the proboscis, for attachment to the host, yet they display rather marked differences between the sexes in many species. Many of these differences are apparently of no advantage to the individuals possessing them and

in some instances appear after the single necessary copulation so they can have no very essential relation to the perpetuation of the species. All evidence seems to point to the fact that the Acanthocephala are, as a group, too far removed from any free living ancestors to make it possible that dimorphism could have been carried over as an inheritance from free living ancestral forms. It then becomes a matter of some interest to examine these instances of sexual dimorphism in the hopes of finding some of the factors responsible for their development.

The somatic differences between the sexes encountered in these parasites constitute two fairly natural classes (a) differences in form and size, and (b) presence in one sex of structures entirely wanting in the other. Under the first of these are included all the differences in body form, in body size, and in proportions of the body or of any of its individual structures while the second, of much rarer occurrence, is possibly based upon incomplete and faulty observations. Frequently structures such as body spines, apparently wanting in one sex, have, upon closer examination, been found greatly reduced in size or obscured by other structures.

Almost invariably the mature female acanthocephalan is larger than the male of the same species. In some instances, however, the difference is so slight that among fully mature specimens some males are as large as the smaller females and in a few instances there is practically no external means of differentiating the sexes. This last mentioned condition is best exemplified in *Plagiorhynchus formosus* VanC. as shown in figures 1 and 2.

Extreme differences in size are to be noted in *Gigantorhynchus hirudinaceus* (Pall.) from the hog. The female of this species may reach a length of 65 cm. while the male rarely attains a length of more than 10 cm. In average, mature, individuals the male is about 4 mm. in diameter while the female measures about 6 mm. Thus in this species the difference in length is much more conspicuous than the difference in diameter. Simple sexual difference in length appears rather late in the development of the individuals of most species that have been

observed. In immature specimens it is impossible to distinguish the sexes without observation of the essential organs of reproduction.


*Plagiorhynchus formosus* VanC.

Fig. 1. Male. Fig. 2. Female. Both figures drawn to same scale.

Another extreme example of difference in length is found in *Heteroplus grandis* (VanC.), the female of which is approximately five times as long as the male (see figures 3 and 4) but only about one-third greater in diameter of the body.


*Heteroplus grandis* (VanC.)

Fig. 3. Male. Fig. 4. Female. Both figures drawn to same scale.

No one has ever demonstrated the presence of cell division in other than germ cells in the body of an acanthocephalan after it has entered its definitive host. In addition to this the writer has shown that in members of the family Neoechinorhynchidae the number of cellular elements is fixed and in structures common to both sexes is

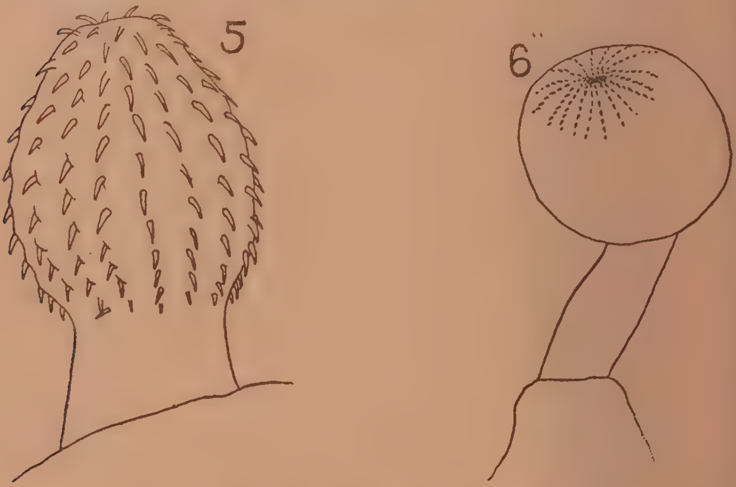
constant in all individuals. Consequently any difference in body size, in members of this family at least, could result only from differences in physiological processes which would permit simple increase in bulk without any corresponding increase in number of cells. Since the start of this differentiation in bulk of the members of the opposite sexes occurs at about the same time that the germ cells start to form it seems possible that simple difference in size of the two sexes may be directly correlated with differences in physiological conditions accompanying the development of the sex cells.

General body form frequently shows marked contrast in the two sexes other than the relative size discussed above. In *Arhythmorhynchus pumilirostris* Van C. the writer has shown that the male has the posterior region of the body distinctly attenuated while the gravid female displays no distinctive difference in diameter of anterior and posterior regions of the body. In this species the musculature of the body wall is also apparently more highly developed in female than in male. In preserved specimens the females present a distinctly wrinkled appearance due to the contraction of the muscles in the body wall, while the males present a perfectly smooth surface on the exterior of the body.

Frequently a portion of the body of a gravid female becomes distorted from the form characteristic of the young female and of the male. Localized distended areas have frequently been attributed to the mechanical effect of the myriads of developing embryos which fill the entire body cavity of the gravid female. Thus in *Neoechinorhynchus cylindratus* (VanC.) and in *N. agilis* (Rud.) the middle third of the body of the female usually shows a distinct enlargement. In some instances the entire body becomes greatly distended, forming a capacious sac for the retention of the embryos as the writer has described in the females of *Filicollis botulus* VanC.

Difference in size and form are not restricted to the body proper. A radical difference in form of the proboscis has been described for the female of *Filicollis*

*anatis* (Schr.). In this species the proboscis of the male and of very young females is of an ordinary type with rows of hooks extending from the extremity to near the base (fig. 5). In contrast with this the proboscis of the female is an inflated spherical organ which bears a star-like crown of hooks (fig. 6), limited in distribution to the anterior face of the structure.




*Filicollis anatis* (Schrank)

Fig. 5. Proboscis of male magnified about 120 diameters. From Lühe 1911, fig. 44.

Fig. 6. Proboscis of female magnified about 30 diameters. Modified from Lühe 1911, fig. 39.

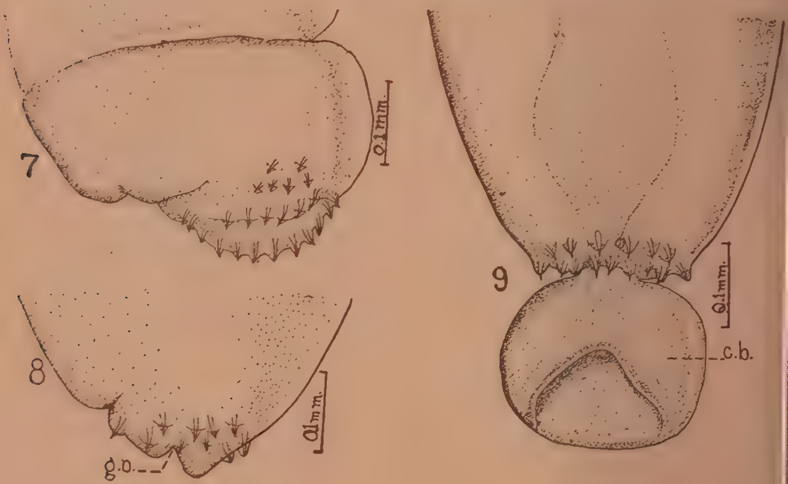
Cuticular spines appear on the body proper of species belonging to certain genera of Acanthocephala. These spines display dimorphism in some instances through dissimilarity in size and in others through difference in distribution. In one species of Rhadinorhynchus the body spines of the female range from 60 to 70$\mu$ in length while those from the same region of the male are only about 28$\mu$ long. In this instance the female shows greater size of spines in just the same manner as greater body size is associated with the females in the Acanthocephala. On the other hand the writer has described two

North American species belonging to the genus Filicollis in which the males bear conspicuous body spines while those of the females are very inconspicuous.

In the genus Corynosoma the cuticular spines cover the anterior region of the body in both sexes. According to Lühe (1911:37) the males of *C. strumosum* (Rud.) and of *C. semerme* (Fors.) possess numerous strong cuticular spines surrounding the genital orifice at the posterior extremity in addition to these on the anterior extremity of the body, but the genital spines are entirely wanting in the females of the same species. This stands as the only instance in literature of the presence of structures in the body of one sex among acanthocephalans entirely absent in the other sex. But since in *C. semerme* the spines around the genital opening of the male are directly continuous with those distributed on the remainder of the body even this instance become an example of relative distribution of body spines rather than separation of genital spines and body spines. In the original description of *Corynosoma constrictum* VanC., the writer failed to discover any cuticular spines around the genital orifice of the females. An abundance of specimens belonging to this species, recently received from Mr. L. B. Dickey, has made it possible to re-examine this question and has thrown considerable light upon the nature of the dimorphic condition of the spines in at least the North American species, *C. constrictum.*

In the new collection mentioned above, I have discovered that young females (Fig. 10) possess genital spines closely resembling those of the male, (Figs. 7 to 9) except slightly smaller in size. In later development, and especially after copulation has taken place these spines become less conspicuous in the female. In some instances I have been able to observe that spines have been apparently forcibly removed from the body as evidenced by the frayed nature of the cuticula in the region of the genital aperture. In this species, as in many other acanthocephalans, a cap-like structure (Fig. 11) covers the posterior extremity of the female following the act of copulation. This structure, for which I propose the name

copulatory cap, is formed by the hardened secretions of the cement gland of the male during the act of copulation. Not all fertilized females carry this copulatory cap for after a time it is apparently rather readily discarded. It seems evident that the spines surrounding the genital orifice of the female aid in holding this copulatory cap in position since they become embedded in the substance




*Corynosoma constrictum* VanC.

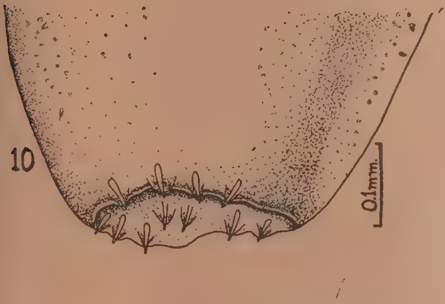
Fig. 7. Posterior region of male with copulatory apparatus fully retracted within body.

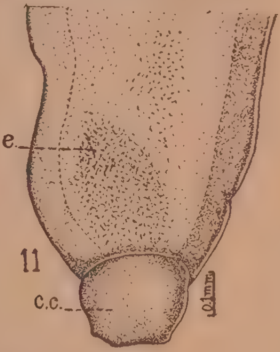
Fig. 8. Posterior region of male showing position of genital spines when posterior extremity is slightly protruded.

Fig. 9. Posterior region of male with copulatory bursa fully extruded.

of the cap. With the final loss of the cap, probably due to the movements of the parasite, it is readily believable that the spines might adhere more firmly to the cap in which they are embedded than to the cuticula where they had their origin and thereby become lost. If copulation occurs more than a single time each successive deposition and removal of a copulatory cap would reduce the number of genital spines until in the older females no spines would remain. In such an instance sexual dimorphism would result from mutilation of the body of one sex to render it unlike that of the other sex.

There has been a general acceptance of the view that the spines surrounding the orifice of the male function during copulation, probably as a means of attaching the male to the female. Advocates of this view have failed to recall the fact that the copulatory apparatus of the




*Corynosoma constrictum VanC.*

Fig. 10. Young female showing spines around genital orifice.

Fig. 11. Gravid female showing copulatory cap which is attached at time of copulation.

male acanthocephalan must be everted from a position far within the body before it can be brought into position for use. When the copulatory bursa containing the cirrus is extruded during copulation the genital spines could not serve for attachment to the female (Fig. 9) because they lie behind the bursa and are completely covered by it.

## CONCLUSIONS

Many theories have been advanced to explain the origin and development of sexual dimorphism. Of these natural selection and sexual selection have probably been most prominently advocated. J. T. Cunningham (1900) has advanced a modified form of inheritance of acquired characteristics as explanation. According to his view organs or structures used directly or indirectly in the reproductive process become modified through function. Thus a tendency toward modification in such structures is passed from generation to gener-

ation. As with most hypotheses regarding secondary sexual characters his evidence is taken largely from higher animals.

Numerous investigations have shown that the development of secondary sexual characters is directly associated with the development of the gonads. In many instances males deprived of the testes have failed to develop characters peculiar to the male sex. Similarly, it has been shown that old individuals after the close of reproductive activity tend to acquire characters intermediate between those characteristic of the two sexes. Unfortunately, because of their endoparasitic habit, the Acanthocephala do not lend themselves to experimental investigations such as those of castration mentioned above. However, in as much as all of the instances of dimorphism cited among the Acanthocephala are restricted to differences in development or relative size of similar structures in the opposite sexes, it seems probable that the physiological conditions accompanying the development of the gonads are directly correlated with the differences in general metabolic processes which control general body growth.

Child (1915:350) has shown that fully formed eggs have a relatively low rate of metabolism. Among the Acanthocephala egg production is not a continuous process. In the individual female the period of development of the eggs is restricted to a single cycle for the gonad becomes entirely used up in the production of the eggs. Consequently the mature female grows considerably in size after the period of egg formation has ceased. This is probably due to the fact that food material during the period of egg formation is largely utilized in that process and at the close of that cycle becomes more generally available for body growth.

In contrast with this the male acanthocephalan continues to produce spermatozoa through an indefinite period of functional activity of the persistant gonads. It seems probable that the continued development of gametes utilizes available elaborated food at the expense of the farther growth of the body. Upon this

basis may be explained why the females continue to increase in size long after maturity is attained while fully mature males of any given species differ but little in size.

While the foregoing attempts to explain the physiological basis for differences in relative development of the body or of restricted regions of the body in the two sexes, no hypothesis can be advanced to explain why the modification of physiological processes regulating growth becomes expressed in such widely varying manners. It is not clear why stimulation to farther growth should in one instance involve the entire body uniformly, in another be confined chiefly to length, and at still other times cause excessive enlargement of restricted areas or of individual structures.

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# THE MORPHOLOGY OF THE ANTORBITAL PROCESS IN THE URODELES *

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In the development of the chondrocrania of almost all Urodeles a small process arises from the lower margin of the trabecula, just in front of the eye. In the early stages of Amblystoma punctatum, where the details of development have been followed more closely, this structure first appears in a larva about 25 mm. long, in which a small cartilage bar develops laterally from the trabecula, considerably back of the choana. This structure has usually been designated the antorbital process, a term most appropriate from the standpoint of its position, and one used throughout this discussion.

Before the antorbital process has appeared, a nasal capsule has begun to develop; first, by the indepedent chondrification of an ethmoidal column, which develops from in front backward, and comes to lie along the median dorsal surface of the nasal sac. Later this column unites to the cornu trabeculae in front and the crista trabeculae behind; and, at about the time that the antorbital process begins to develop from the trabecula, a cartilage bar chondrifies laterally from the posterior end of the columna ethmoidalis, partially covering the nasal sac at the choana. By a further growth, this bar expands laterally, anteriorly and posteriorly into a broad plate of cartilage, which, covering the nasal organ, forms the roof of the capsule. Earlier writers on the chondrocranium of the Ichthyopsida (Winslow, 1898; Terry 1906) speak of this plate as the lamina cribosa, a rather inappropriate term, for it is evident that this structure

* Contributions from the Zoological Laboratory of the University of Illinois, No. 163.

can not be the homologue of the cribiform plate of mammalian anatomy, since the olfactory nerve does not pass through any portion of it. Accordingly it would seem that the term planum tectale would more adequately express the function and the position of this cartilage.

In the younger stages of Amblystoma, the antorbital process and the planum tectale are far removed from each other, the former having no association whatsoever with the nasal region. During later development, however, the distal part of the antorbital grows forward, while the base of the tectale extends farther backward, so that in a larva 34 mm. long, these structures have come to lie very close to each other. During the later larval period, the cornu trabeculae, which supports the anterior parts of the nasal organ, extends backward toward the antorbital and the tectale; and, in a larva at the end of metamorphosis, these structures have all united to form the lateral and the posterior walls of the nasal capsule.

It is evident, therefore, that the antorbital process, although having its origin some distance back of the nasal region, is destined to become with the planum tectale, the posterior wall of the nasal capsule, which is pierced by a single opening, the foramen orbito-nasalis, through which the branches of the fifth nerve pass to the olfactory organ.

Considerable diversity of opinion has existed in the past, in regard to the homology of this cartilage bar, which arises from the trabecula considerably back of the nasal region, but later becomes a part of the posterior wall of the nasal capsule. Throughout the literature, the terms palatine cartilage and antorbital process are used interchangeably in its designation, the latter possibly being more commonly employed; while Parker, in a series of extensively illustrated papers on the skull of the Anura and Urodela has employed the term ethmo-palatine. Gaupp (1893), in his work on the chondrocranium of Rana fusca, held that the antorbital process of the Urodeles is homologous with the pterygoquadrate arch of the Anura; and he uses the terms "Antorbitalfort-

satz'' and ''Cartilago palatina'' with reference to the same structure. It may be remarked parenthetically, that the terms palatine cartilage or palato-quadrate arch, frequently applied to the pterygoquadrate is incorrect, as it contains no palatal element, and no part of the palatine bone is derived from it.

In the development of the chondrocranium of Cryptobranchus alleghaniensis, possibly a more primitive Urodele, some light is shed upon the history of this antorbital process. In a larva, two weeks after hatching, when the cristae trabeculorum are already well-developed there is no evidence of a developing antorbital. Slightly posterior, however, to the position of its probable appearance, procartilage cells have formed in the surrounding tissue, lateral to the trabecula; and these cells continue posteriorly into the anterior end of the pterygoquadrate, extending forward from the hinge of the lower jaw. In a larva five weeks old, these procartilage cells have chondrified; the pterygoquadrate now reaches farther forward, and unites to the side of the trabecula in the position from which the antorbital process normally develops in other Urodeles. In this stage, there is no extension forward of a cartilage bar from the junction of the pterygoid with the trabecula; but in a larva three months after hatching, a small process reaches forward from the end of the pterygoquadrate toward the nasal capsule, and an antorbital process has assumed proportions similar to that in Amblystoma. My oldest larva of Cryptobranchus does not show any connection between the antorbital process and the nasal capsule; it is probable, however, that in a later stage these parts would be united, for the nervous supply and the associated cartilages are similar to those in Amblystoma.

In no other Urodele, as far as I have been able to discover, with the single exception of the Siberian genus Ranodon (Wiedersheim, 1876; fig. 69) is there a similar connection of the pterygoquadrate with the anterior part of the skull. In a larva of Spelerpes fuscus (Wiedersheim, 1876; fig. 108) there is a cartilage bar directed posteriorly from the nasal capsule toward the pterygo-

quadrate, which has been called the maxillary process; and the proximity of these two structures would suggest an earlier continuity between them. Elsewhere in all described Urodeles, the extent of the pterygoquadrate forward from the quadrate is variable throughout the order; and in the adult Cryptobranchus (and this holds true for the Japanese japonicus, as figured by Parker, 1876) the connection between the pterygoid and the structures farther forward is lost. In the chondrocranium of Epicrium glutinosum, the blind caecilian of the tropics, the pterygoid process reaches well forward toward the nasal region; and the proximity of the antorbital to the pterygoid suggests that here, as in some of the Urodeles, these structures may have been at one time more closely related.

In all of the Anura, on the other hand, the pterygoquadrate arch is connected throughout life with the posterior wall of the nasal capsule. In this respect, Ranodon and Cryptobranchus more closely approach the Anura than any other Urodele; for in the remainder of the group, there is no connection of the pterygoquadrate with the anterior part of the cranium.

It is usual to regard the pterygoquadrate arch of the Anura as the homologue of the upper jaw of the Elasmobranch, which, with the development of the osseous upper jaw of the higher groups has lost its original function as part of the feeding apparatus, and has fused with the cranium, thus contributing toward the posterior wall of the nasal capsule. In the chondrocranium of the Elasmobranch, there is no anterior extension of the pterygoquadrate beyond the curve of the upper jaw, to form any integral part of the nasal capsule; but in all of the Anura, as far as I know, the side wall of the capsule is apparently a continuation forward of the pterygoid, beyond its connection with the cranium. In Pipa americana, a small triangular cartilage plate, the ethmo-palatine of Parker, continues forward from the pterygoid and partially covers the caudal parts of the nasal organ; while in Bufo and Rana, the side wall of the capsule, better designated

the lamina externa, is likewise continuous with the anterior end of the pterygoquadrate.

In Cryptobranchus, then, these relationships between the pterygoid and the nasal capsule, as found in the Anura, are carried over into the Urodela; and it would seem that the antorbital process, the pterygoid and the planum tectale of the Urodela may be readily homologized with these structures in the Anura. That being true, it would apparently follow that the antorbital process in Cryptobranchus and perhaps in all Urodeles, is, at least in its basal part, derived from the anterior part of the pterygoquadrate arch; while the more distal portion which must be the homologue of the lamina externa of the Anura, may be a new formation. It may be remarked, that in both the Anura and the Urodeles, the antorbital process unites with the cornu trabeculae, a structure clearly homologous throughout the class Amphibia, thus furnishing a further clue to its relationships.

In the early stages of the chondrocranium of Salamandra maculata, a Urodele in which the pterygoquadrate does not reach forward into the nasal region, the antorbital process arises from the trabecula much as in Amblystoma. During its development, the planum tectale, which forms the roof of the nasal capsule, develops laterally from the posterior end of the columna ethmoidalis; and, curving ventrally, covers the posterior and lateral parts of the nasal organ. In a larva, 38 mm. long, the anterior end of the distal part of the antorbital, which has developed forward toward the capsule, has come to lie just beneath and slightly posterior to the lateral margin of the planum tectale; so that these two structures are separated by a wide gap, through which the ophthalmicus and the superficialis branches of the fifth nerve pass to the nasal organ. Thus the antorbital process is ventral to these nerves. In all Urodeles, with the exception of Necturus and Amphiuma, in which the antorbital process does not unite to the structures farther forward, and probably in the later stages of Salamandra, this wide gap is reduced to an orbito-nasal foramen, which

pierces the posterior wall of the nasal capsule and conducts the rami of the fifth nerve into the nasal cavity. In the chondrocranium of Bufo americana, these same nerves pierce the posterior wall of the capsule just above the pterygoquadrate, where it joins the cranium; the same is true in Rana and Pipa, although in the latter, some modifications in the capsule have occurred, making the comparisons to the Phaneroglossa more remote. Since it is customary to regard nerves and their distribution as sufficient criteria for the determination of homologous structures, it would apparently follow that the orbito-nasalis foramen has been reduced from the large gap between the planum tectale and the antorbital process; and that these foramina in the Urodeles and the Anura occur in homologous parts. Accordingly that portion of the posterior wall of the nasal capsule dorsal to these nerves must be a derivative from the planum tectale, while the cartilage immediately beneath them is as clearly antorbital in origin, or in the Anura and Cryptobranchus clearly pterygoidal.

## SUMMARY

The antorbital process of the Urodela arises from the lower margin of the trabecula, considerably back of the choana; during the later stages it unites with the structures farther forward, and forms a part of the posterior wall of the nasal capsule. In Cryptobranchus alleghaniensis the pterygoquadrate arch joins the side of the trabecula in the position from which the antorbital normally develops in other Urodela; and in this respect Cryptobranchus more closely approaches the Anura, in which the junction of the pterygoquadrate to the cranium is the characteristic condition.

The rami of the fifth nerve pass into the nasal capsules of the Urodela through an orbito-nasal foramen, dorsal to the antorbital process; while in the Anura, these same nerves pass through a foramen just above the pterygoid process, where it joins the cranium. That part of the posterior wall of the nasal capsule in the Urodela, ventral to these nerves is clearly antorbital;

while in the Anura, this ventral portion is as clearly pterygoid.

The basal part of the antorbital process in Cryptobranchus, and possibly in all Urodeles is derived from the pterygoquadrate arch, and is homologous with the anterior part of this arch in the Anura.

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# CNIDOSPORIDIA IN THE VICINITY OF URBANA[1]

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The writer has been studying, for some time, Cnidosporidian parasites of fishes and insects from the vicinity of Urbana, Ill. The object of this study is to determine: 1) what forms do occur in this locality; 2) to what extent is the infection carried on; and 3) what is the effect of infection upon the host body. The study is still under way; the brief summary of the results obtained up to the present will be stated in the following pages.

[1] Contributions from the Zoological Laboratory of the University of Illinois, No. 164.

## I. MYXOSPORIDIA[2]

The following eighteen species of fish and one species of reptile have been subjected to careful examination. It may be understood that the fish were collected from the drainage at Urbana, unless otherwise stated.

| Host-species | Locality | Month of examination | Number of individuals examined | Number of individuals infected | Organs infected | Myxosporidian |
|---|---|---|---|---|---|---|
| *Ambloplitis rupestris* | Stony Creek | November | 2 | 0 | .... | .... |
| *Ameiurus melas* | .... | Oct. and Nov. | 5 | 0 | .... | .... |
| *A. natalis* | Stony Creek | November | 3 | 0 | .... | .... |
| *Carpiodes difformis* | .... | May | 1 | 1 | Branchia | *Myxobolus discrepans* Kudo |
| *C. thompsoni* | Stony Creek | November | 1 | 1 | Gall-bladder | *Myxobolus* sp. (?) Few spores |
| *Catostomus commersonii* | .... | October | 5 | 4 | Gall-bladder | *Chloromyxum catostomi* Kudo *Myxidium* sp. |
| *C. nigricans* | Stony Creek | November | 1 | 0 | .... | .... |
| *Eupomotis gibbosus* | Crystal Lake | June | 1 | 1 | Gall-bladder | *Chloromyxum trijugum* Kudo |
| | | | | 1 | Ovary | *Wardia ovinocua* Kudo |
| *Lepomis cyanellus* | Stony Creek | November | 3 | 1 | Urinary bladder | *Henneguya mictospora* Kudo |
| | Crystal Lake | June, July | 36 | 7 | Mesentery, etc. | *Myxobolus mesentericus* Kudo |
| | | | | 36 | Kidney | *Mitraspora elongata* Kudo |
| *L. humilis* | Stony Creek | November | 2 | 1 | Urinary bladder | *Henneguya mictospora* Kudo |
| | | | | 1 | Ovary | *Wardia ovinocua* Kudo |
| *L. megalotis* | Stony Creek, Homer | November | 6 | 6 | Gall-bladder | *Chloromyxum trijugum* Kudo |
| *L. pallidus* | Crystal Lake | June, July | 8 | 3 | Gall-bladder | *Chloromyxum trijugum* Kudo |
| L. sp.[3] | .... | October | 26 | 5 | Gall-bladder | *Myxidium* sp. A few spores *Myxobolus* sp. (?) Few spores |
| *Micropterus dolomieu* | Stony Creek | November | 1 | 0 | .... | .... |
| *M. salmoides* | Stony Creek | November | 1 | 1 | Urinary bladder | *Henneguya mictospora* Kudo |

[2] Descriptions of the Myxosporidia mentioned here are published in the writer's work on Myxosporidia (Illinois Biological Monograph Vol. V) which is now in press.

[3] The fish were less than three centimeters in length, and could not be identified.

| Host-species | Locality | Month of examination | Number of individuals examined | Number of individuals infected | Organs infected | Myxosporidian |
|---|---|---|---|---|---|---|
| *Notropis blennius*....... | Homer | November | 2 | 2 | Gall-bladder | *Sphaerospora* sp. (?) A few spores |
| | | | | 1 | Muscle | *Myxobolus orbiculatus* Kudo |
| *N. gilberti*............ | Stony Creek | November | 1 | 1 | Muscle | *Myxobolus orbiculatus* Kudo |
| *Pomoxis annularis*...... | Crystal Lake | July | 1 | 1 | Gall-bladder | *Chloromyxum trijugum* Kudo |
| *Trionyx spinifera*....... | Crystal Lake | July | 1 | 1 | Kidney | *Myxidium americanum* Kudo |

As will be seen from the above, the myxosporidian infection among the common fish in this locality is heavy. Only five out of eighteen species of fish were proved to be free from infection at the time of examination. Yet too much emphasis can not be laid upon the absolute absence of Myxosporidia in these fish, as the number of individuals in each of these five species was not great and besides observations were not made during the summer months.

The writer could not collect, and study the fish throughout the year. In the fish obtained during colder months, there was strong evidence which suggested that only plasmotomous multiplication of the parasites took place. On the other hand, in the specimens collected in June and July, remarkably rapid growth of parasites due to plasmotomous as well as sporogonic development were clearly noticed. This was well demonstrated in the case of *Mitraspora elongata* Kudo, parasitic in the kidney of *Lepomis cyanellus* caught in Crystal Lake. Early in June vegetative forms and spores were seen to be present in the lumen of the urinary tubules of the kidney of host, while in the latter part of June and in July the vegetative forms became considerably larger and larger, and appeared as more or less conspicuous cysts in the tissue of the kidney, forming frequently numerous small whitish pustules on the surface of the organ. These observations simply verify similar observations made by several investigators especially on such a form as *Myxobolus pfeifferi* Thélohan.

As to the effect of the parasites upon the host-body, the writer has but little to state. In the case of infection of the gall-bladder or urinary bladder, the host fish did not show any recognizable effect which may be attributed to the myxosporidian infection. This has been true in almost all cases of the so-called "free" forms. In the tissue-infecting species, however, some effect was noticed. The heavy infection of *Myxobolus discrepans* Kudo on the branchial lamellae, apparently reduced the activity of the host, *Carpiodes difformis,* so that the host fish was caught with a small net without much trouble, and also seemed to have quickened the death of the host which occurred shortly after its capture.

It is noticable that even very young fish, *Lepomis* sp. which were less than three centimeters in length harbored a few spores in their gall-bladder which fact must be considered seriously when they are used as experiment animals. It is also noticable that so far the writer has not encountered any species which would produce cysts in the subcutaneous tissues of the body or fins of the host.

## II. MICROSPORIDIA[4]

Little is known about North American Microsporidia. In connection with Myxosporidia, the writer has also been studying Microsporidia. The study has just begun, yet the writer feels justified in stating that this group of Cnidosporidia plays some rôle in certain aquatic arthropods.

The larvae of *Culex pipiens* and *Anopheles punctipennis* and the nymphs of *Baetis* sp. (?), which were collected in October from the drainage at Urbana, have been found to be infected by three different Microsporidia respectively.

Out of 38 larvae of *Culex pipiens* examined, six were found to be infected by *Thelohania magna* Kudo. The adipose tissue and body cavity were the seat of infection, other organs being so far free from the infection.

[4] Full account of these Microsporidia will be published in the Journal of Morphology.

Twenty-two larvae were kept in the laboratory, and metamorphosed into pupae and adults. Thirteen pupae and nine adults were examined. In one adult were seen a few spores in fresh smears. Careful examination of numrous sections of larvae failed to reveal the slight infection whatsoever. This may be interpreted as indicating that the larvae became infected either when they were very young or when they swallowed a large amount of infected tissue of the larva dead from the infection and underwent decaying at the bottom of the pool where they were found, so that the heavy infection resulted in a comparatively short time.

The infected larvae were more whitish opaque in color than normal, with more or less distended thorax. Yet they were as active as normal ones. However, they died more rapidly than majority in the laboratory. Although there has been one case of ambiguous slight infection in an adult, the parasites seem to exercise a fatal effect upon the host, and the larvae once infected, perish without completing their life cycle.

This is the second Microsporidian found parasitic in the dipterous insects under discussion, although there have been some doubtful cases which did not furnish the necessary proof to show their belonging to Microsporidia. The first microsporidian parasite of mosquitoes was described by Hesse in 1904 from France, who noticed a few larvae of *Anopheles maculipennis* infected by *Thelohania legeri* Hesse. The seat of infection was adipose tissue as in the American form. Hesse however states that the infection was rare and the infected larvae did not seem to suffer at all from the parasites.

In two out of twelve larvae of *Anopheles punctipennis* examined, another Microsporidian was noted to occur in the adipose tissue. The small number of specimens and the smear preparation do not allow the writer to report the details as the observation is still incomplete. The effect of the parasite upon the host also remains to be determined in future.

In nine out of thirty nymphs of *Baetis* sp. (?). examined, third Microsporidian was found to occur exclu-

sively in adipose tissue. The infected nymphs could easily be distinguished from the healthy ones by their opaque appearance. They however did not seem to suffer from the infection. Further details still are needed to complete the observations.

The Microsporidian nature of the latter two forms can not be doubted, because the writer could determine every characteristic of Microsporidian spores in both of them; i. e., the characteristic appearance of spores and the presence of a polar filament in the spore which can be made to extrude under suitable treatment.

SUMMARY

Myxosporidia are common parasites among fish in the vicinity of Urbana, Ill. The infection is heavy in many cases. The effect of the parasites on the host body is in some cases fatal.

Microsporidia seem to be also common among some aquatic insects in the same locality. The larvae of *Culex pipiens* appear to receive mortal influence by its parasites, *Thelohania magna* Kudo.

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## SOME LIMITING FACTORS IN THE USE OF FUNGUS DISEASES FOR COMBATING INSECT PESTS*

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Insects are attacked in nature by many fungus diseases. Sporadic cases of such diseases are common, and may be found by a diligent collector at almost any time. Occasionally, however, some of these diseases appear in epidemic form so as almost to exterminate locally, insect species which previously had been abundant.

That house flies are commonly decimated in autumn by a fungus disease of that insect, *Empusa muscae,* is well known. Even the most superficial observer can

* From the Entomological Laboratories of the Illinois State Natural History Survey, S. A. Forbes, Director.

scarcely have failed to notice dead bodies of house flies in Autumn sticking to window panes and to other surfaces, with the abdomen whitened by the spores and spore producing bodies of this fungus, and often with a broad circle of the discharged spores adhering to the surrounding surface so as to form a sort of halo about the dead insect. Other species of *Empusa* attack grasshoppers and plant lice, as well as many other kinds of insects, and epidemics of another fungus disease, *Sporotrichum globuliferum*, have often contributed materially to the suppression of the chinch bug during outbreaks of that notorious pest. It would be exceedingly difficult to grow citrus fruits profitably if the scale insects which attack these fruits were not largely destroyed and thus held in check by fungus diseases. Indeed, one of the authors has himself observed a mortality of 95 per cent in the scale insect, *Aspidiotus ancylus*, on pecans in Georgia, due entirely to fungus disease.

The fact that fungus diseases at times cause the destruction of great numbers of insects has aroused much popular as well as scientific interest; and since many of these fungi may easily be cultivated in the laboratory on non-living culture media, the question whether artificially produced epidemics of such diseases might not afford a ready means for controlling outbreaks of injurious insects has received much serious attention. The idea of employing their fungus diseases to control the ravages of noxious pests is not a new one. DeBary, the Tulasne brothers and others, as early as the middle of the last century, called attention to the important natural check on destructive insects afforded by the "white muscardine", *Isaria densa* Link., and similar organisms, and since that time many workers have attempted to produce epidemics of such diseases by artificial means for the purpose of combating insect pests.

Among the host of investigators who have worked on this general problem, Krassilschik (1884) employed the so-called "green muscardine", *Metarhizium anisopliae* Metch., to combat the beet weevil, *Cleonus punctiventris* Germ.; Rorer (1910) employed the same fungus in Trini-

dad to combat the sugar-cane frog-hopper; Forbes (1888), Snow (1889), and others have attempted to use *Sporotrichum globuliferum* Speg. to control the chinch bug; Rolfs (1907) and Fawcett (1908) have used *Sphaerostilbe coccophila* Tul. and *Ophionectra coccicola* E. and E. against the San Jose scale and the purple scale on the orange; and the last two investigators have also employed various other fungus diseases to combat the white fly in the citrus groves of Florida.

Very diverse opinions have been expressed by investigators who have worked upon this problem, concerning the success of their experiments and the promise of this method of insect control for practical work. Krassilschik claimed to have produced an epidemic of "green muscardine" among the weevils in the beet fields at Smelk, which destroyed from 50 to 80 per cent of these pests. Rorer reports the destruction of as many as 93 per cent of the sugar-cane frog-hopper in his field experiments in Trinidad, and most promising results have also been reported from work with the fungus diseases of scale insects and of the white fly in Florida. On the other hand, however, some workers have reported the complete failure of their experiments, and have expressed grave doubts concerning the practical utility of the method. Between these extremes, all degrees of success and failure have been reported, and all degrees of optimism and pessimism expressed by investigators who have studied the problem. On the whole, perhaps, a summation of these various reports and opinions tends rather to discredit than to recommend the method.

In spite of the disrepute into which the insecticidal use of fungus diseases has fallen in many quarters, the startling destructiveness of occasional natural epidemics of these diseases remains, and their importance as a constantly present natural check upon insect oscillations cannot be denied. These facts, therefore, together with the frank differences of opinion expressed by students of the subject, have seemed to justify reopening the question, and have led to the organization of a series of studies of which the present paper is a partial report.

The effectiveness of entomogenous fungi in both natural and artificially induced epidemics, appears to depend very largely upon climatic conditions. Indeed, those students of the subject who are most pessimistic concerning the practical utility of fungus diseases in insecticidal operations, recognize their great effectiveness under favorable weather conditions, but hold that sufficiently favorable conditions to insure success are encountered too rarely to justify the enthusiasm for the method which some of its advocates have expressed.

The procedure followed by former students of the subject has usually been to propagate some species of fungus diseased on artificial media, and to distribute the spores produced or the resulting culture of the organism, in fields or in other situations where the insect pest against which the operation was directed happened to be abundant. In such a case the results of the test and the conclusions of the operator are determined by the weather conditions which chance to prevail at the time. Laboratory studies generally have been little more than field tests in miniature, and usually with as little attention given to the precise relation between the results obtained and the conditions governing the test.

In organizing the present series of studies it was proposed to analyze the problem thoroughly and to study its various elements one by one: to proceed under carefully controlled conditions, and by changing certain of these conditions one at a time, to find how various degrees of temperatures, various percentages of humidity, and various other fators may influence the germination of the spores and the power of the fungus to penetrate the body of its insect host; to find how cultivation of the fungus on artificial media may influence its virulence or power to attack its proper insect host; to find how temperature, humidity and other factors may influence the power of the insect to resist infection when exposed to contamination with a fungus disease: and finally, in the light of the data thus accumualted, to canvass the meteorological records and to determine if practicable in what habitats of what localities during what months or seasons, fungus diseases

may or may not be employed to combat outbreaks of noxious insects with a reasonable assurance that the operation will be successful. The present report relates to some of the effects of different degrees of temperature and different percentages of humidity upon the behavior of an entomogenous fungus toward one of its insect hosts.

The "green muscardine" of Metchnikoff, *Metarhizium anisopliae,* was chosen as the pathogenic agent in this series of studies because of its cosmopolitan distribution, because of its power to attack and destroy insects of many widely separated taxonomic groups, and because it has been employed in field operations with reputed success by several former investigators of the subject. For the insect host, pupae of the giant American silk worm, *Samia cecropia,* were chosen, because they are common and may easily be obtained in ample numbers, because they are large and easily handled and observed, because they are quiescent and more easily managed in the exposure cages than the active stages of any insect could possibly be, and finally, because they are available throughout the year if collected in the fall and kept in cold storage.

Constant temperatures of the various degrees indicated were maintained in a battery of six incubators, and in each incubator was provided a series of large dessicators, the atmosphere within each of which was maintained at a constant relative humidity by means of sulphuric acid in appropriate dilutions. This method for maintaining any desired degree of relative humidity is fully described and tables of dilutions are given by N. E. Stevens, Phytopathology, vol. 6, 1916, pp. 428-432. Thus, a predetermined series of humidity exposures could be made at the temperature maintained in each incubator, affording a temperature-humidity curve for each complete set of tests.

Spores both from pure cultures grown on potato and from infected cecropia pupae were employed in the course of the work, and in each test two lots of pupae were used, which were treated with these spores in two different ways. The pupae in one of these two series were simply

dusted with the dry spores, while an emulsion of the spores in sterile physiological salt solution was prepared, and injected by means of a hpodermic syringe into the sub-hypodermal tissues of the pupae in the second series, each pupa in the inoculated series receiving many times the minimum fatal number of spores. That this method of inoculating the pupae is not injurious mechanically, is conclusively demonstrated by the fact that other pupae receiving injections of sterile physiological salt solution, similarly administered but several times greater in volume, survived the experience apparently uninjured and developed into normal adults.

The case history of this disease in the cecropia pupa presents several rather sharply defined stages which afford an excellent index to the effect of any combination of temperature and humidity conditions. The stages may be outlined briefly as follows: (1) The spores must germinate and penetrate the body wall of the pupa in sufficient numbers to overcome the natural resistance of the insect. This conquest of the host animal by the disease, and the development of the fungus at the expense of its tissues may be recognized by the characteristic hardening of the body of the insect commonly called mummification, and the two series of pupae just described afford an accurate check at this point, on those conditions which either entirely prevent the germination of the spores in contact with the pupa, or prevent their penetration of the body wall of the insect in numbers sufficient to infect the animal. (2) Having completed its development within the body of its host, the fungus must again penetrate the body wall to reach the exterior where the new crop of spores may be produced in a position most favorable for dissemination. This stage is characterized by the appearance of velvety-white masses of hyphae which appear first through the thinner portions of the integument between the abdominal segments, but which eventually may cover the entire surface. (3) The first evidence of spore formation consists of the appearance upon the velvety-white masses of aerial hyphae of small, irregular, light olive-green patches,

which increase in size until they become confluent. (4) The final stage is the ripening of the spores, which are a dark, gray-olive in color, and which typically form a solid layer from one to two millimeters thick over the entire surface of the pupa.

Time will not permit a discussion of the details of individual experiments, but a summary of the general results presents the following facts which seem especially worthy of note: *A.* Even at optimum relative humidities, development of the fungus in these tests did not occur in either series of pupae at temperatures below 14° nor above 38° C. *B.* At 35° C. aerial hyphae may appear on the surface of a mature mummified specimen, but a new crop of spores will not be formed. At this temperature the injected spores may infect and kill the insect host, but the fungus can not propagate itself. *C.* The most rapid development of the fungus, or the shortest time observed between exposure to infection and the ripening of a new crop of spores (17 days for the injected, and 29 days for the dusted series), occurs at 30° to 31° C. *D.* Spores are produced in greater abundance at temperatures between 18° and 26° C., which appears to be the optimum temperature range for this species of entomogenous fungus. *E.* At optimum temperatures, constant relative humidities below 80 per cent appear to be prohibitive. At constant relative humidities between 80 per cent and 90 per cent infection does not occur in the dusted series of pupae, and while the disease in the inoculated series will progress to the mummification stage, the subsequent external development of the fungus and especially the formation of spores is very scanty. Relative humidities between 95 per cent and 100 per cent constitute the optimum range for this species.

It is needless to say that combinations of temperatures between 18° and 26° C. with relative humidities between 95 per cent and 100 per cent of any considerable duration are not common, especially during periods when injurious insects are most abundant, unless it be in tropical or sub-tropical regions or possibly in subterranean habitats. Further investigations are under way or pro-

jected which are designed to show what minimum exposure to optimum or favorable conditions may alternate daily with unfavorable or even prohibitive conditions and still permit a normal development of the fungus, and studies are being made of some of the problems relating to the behavior of this fungus under subterranean conditions upon which it is hoped a further report may be made in the near future.

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## NOTES ON THE LIFE-HISTORY OF A CRANE-FLY OF THE GENUS GERANOMYIA HALIDAY (TIPULIDAE, DIPTERA)

By C. P. Alexander and J. R. Malloch, Natural History Survey, Urbana

The genus *Geranomyia* was erected in 1833 by Haliday (Entomol. Magaz., vol. 1, p. 154) for a species, *G. unicolor,* occurring near the sea-shore in England and Ireland. Since the date of its establishment, approximately eighty species have been added to this genus, the members being found in all the major regions of the world.

The habits of the adult flies have been discussed rather frequently in the literature but data on the immature stages are quite lacking. When we consider the comparatively large size of the genus and its wide distribution throughout the world, this fact becomes very striking and *Geranomyia* may be considered as being the largest genus of crane-flies that has thus remained unknown. Mr. Malloch, one of the authors of this paper, was the first to locate the breeding-haunts of a species of *Geranomyia* and to ascertain the rather peculiar life-history. The notes made at the time of this original discovery in 1917 and the subsequent observations made by both authors in 1919 are briefly recorded in the present article.

The adult flies of species of *Geranomyia* are all of medium size. They are distinguished from all other crane-flies by the structure of the elongate rostrum which is approximately one-half the length of the body,

with the paraglossae very elongate and appearing as slightly recurved lobes, the palpi being situated not far from the base of the rostrum. All other crane-flies with the rostrum conspicuously elongated have the palpi reduced in size and borne at the extreme apex. Because of this elongate beak, the flies of this genus superficially resemble very large mosquitoes from which they are readily distinguished by the family characters, the long and excessively slender legs, the almost invariable presence of an enclosed (discal) cell on the wings and the complete lack of scales on the body and wings.

The adult flies are often very abundant and may be swept in numbers from vegetation in the haunts which they frequent. The authors found one of the four species occurring in northeastern North America, *Geranomyia canadensis* (Westwood), very commonly at Alto Pass, Union County, Illinois, on June 6, 1919. At this place there is a low limestone embankment formed by a cut of the Mobile and Ohio railroad, about one hundred yards south of the station. The almost vertical surface of this embankment is continually moist with water percolating from the saturated soil above. On the face of this small cliff the immature stages are spent as described hereinafter and the adult flies occur in numbers in the immediate vicinity. In the evening they appear in small swarms of usually three or four individuals, dancing about only an inch or two from the face of the cliff. The swarming flight is nearly horizontal and in the form of a figure 8, very rapid, but covering a distance of only three or four inches. In repose, the species occur on the face of the wall where they are usually to be found in the act of "bobbing" up and down. In copulation, the pairs rest on plant stems near these haunts, the female above, the male below and partly dorsad of his mate, the posterior legs of both sexes hanging free. The feeding habits of the flies are now comparatively well-known. Knab and other students found that the present species feeds on the nectar of tubular flowers, preferably Compositae (*Eupatorium*, *Solidago*, *Aster*, *Silphium*, *Rudbeckia*, *Cacalia*, *Verbesina* and others), usually in the late

afternoon and evening. The other species whose methods of feeding are known have habits that are very similar to the above. The eggs are deposited in moist situations such as the one described above.

The most striking feature of the life-history is its extreme brevity. This duration was determined in the following manner: In 1917, the Floriculture department of the University of Illinois laid out a portion of the grounds on the south campus as a garden and devoted a small part to flowers found in rocky situations. In this part they installed a bubbling fountain among some rocks at one side of the winding, declivitous walk, the water flowing from the fountain being conducted to the sewer some distance away by means of an open gutter along one side of the walk. This gutter had become obstructed by vegetable growth and while examining an artificial pond near the garden for mosquitoes, the small pools in the gutter were also examined to discover if any mosquito larvae were present. No mosquito larvae were found but among the aquatic insects along the gutter were some interesting forms, including an Anthomyiid, *Lispa tentaculata* (De Geer), some species of Dolichopodidae, about three species of Chironomidae, and larvae, pupae and imagines of *Geranomyia canadensis*. The larvae and pupae of the last named species were found on the surfaces of the rocks over which the water from the fountain flowed very swiftly, some on the vertical portions, and were remarkably conspicuous owing to the fact that the surfaces on which they lay were coated with a rusty colored diatomaceous deposit from the water, which is of artesian origin.

Several of the larvae were removed to jars and kept alive for over a week but failed to pupate. Adults were found commonly alongside the gutter, resting on the vegetation, feeding on the nectar of flowers or in copulation. In 1919, this bubbler in the Rock Gardens was turned on for the season on April 25. On May 24, the rock surface was thickly covered with diatomaceous ooze but no larvae could be found and, if present, must have been very small. On June 28, just five weeks later, half-

grown and fully-grown larvae and a few cast pupal skins were found. This proves that the entire life-cycle to the adult condition is not more than two months and probably only six or seven weeks. At Alto Pass, in the situations previously described, the larvae of *Geranomyia canadensis* were found living in the irregularities and crevices on the wet face of the cliff. They were found lurking in delicate, silken tubes covered with a deposit of silt and diatoms. They emerged from these cases to feed on the exposed surface of the wet rocks during twilight and even during the hours of sunlight but upon being disturbed or alarmed they retreated instantly and with great agility into their tubes. The pupa occurs in a short, nearly vertical, burrow in the same situations as the larvae; here they rest with only the long, conspicuous/ breathing-horns projecting from the entrance to this burrow. When transformed, the empty pupal skin projects from the mouth of the burrow nearly to the ends of the wing-sheaths. Numerous larvae, three pupae and many cast pupal skins were found. The very scanty number of pupae as compared with the abundance of larvae and pupal skins leads us to believe that the pupal existence is of very short duration, else this stage would be found more often.

It is probable that the flies pass the winter in the larval condition, although this has not been proven. In the green-houses of the Department of Floriculture of the University of Illinois, the adult flies were found in large numbers throughout the winter. On February 26, 1920, at least one hundred individuals were seen in one of the buildings where the heat was maintained at approximately 70° in the day and 60° at night. Many of these flies were gravid females, a few were teneral, as though newly emerged, and still others were in copulation. However no evidences of the immature stages could be found in spite of a diligent examination of all possible situations wherein these flies might be breeding. The only possibility of their breeding in these buildings would appear to be in damp earth since no situations

comparable to their out-door breeding situations are maintained in the green-houses.

Last fall (1919) a number of adults were found in the greenhouse at the University Vivarium building, resting on the sides of the small overflow troughs or channels. Several times since, efforts have been made to discover if the species passes the winter there and, if so, in what stage. No stage has so far been discovered in this situation, only adults in spider's webs remaining as evidence of their occurrence there.

It may be seen from the above account that the general features of the immature stages are quite in agreement with other members of the tribe Limnobiini, the larvae living in silken tubes into which they retreat when danger threatens. A similar habit is found in the genera *Limnobia, Dicranomyia, Rhipidia, Discobola, Elliptera, Antocha* and others.

The immature stages may be briefly described as follows:

*Larva.*—Length, 12—12.5 mm.
Diameter, 0.8—0.9 mm.

The living larva is grayish subhyaline in color, the alimentary canal and the tracheae showing very clearly through the integument; on the posterior lateral portion of the prothorax a large orange area is evident; the transverse welts on the segments dark brown. Upon dropping the larvae in alcohol they soon become opaque white.

Body moderately long and slender, the thoracic segments gradually decreasing in length from the prothorax to the metathorax; first abdominal segment short, the abdominal segments gradually elongated to the fifth, then shortened to the end of the abdomen. The ventral surface of the last two thoracic segments and the first eight abdominal segments are each provided with a basal transverse welt which is densely set with microscopic short hairs or points. On the mesothorax and metathorax these are broad, the spicules most dense medially to form a broadly triangular region, the lateral portions with

fewer hairs; the area on the first abdominal segment is much smaller than those on the succeeding segments and not raised into a welt; the area on the eighth abdominal segment is less conspicuous than those of the preceding seven segments which are raised into broad oval welts. The areas on the dorsal surface of the segments are much narrower and not raised into welts; they occur as a narrow, parallel-sided band on the anterior margin of the metathorax and on abdominal segments two to eight, occupying a position nearly opposite the welts on the sternum but with no connection across the pleural region except the areas on the metathorax and the eighth abdominal segment where the bands completely encircle the body although less developed on the pleural regions. The body setae are very small and scattered, a widely separated pair a short distance caudad of the ventral abdominal welts, on the thoracic segments occupying corresponding positions but with two setae to a puncture. The dorsal setae are very small and widely separated, situated nearly midlength between the welts.

The spiracular disk is very similar to that found in the genus *Dicranomyia*, the spiracles being very large, elongate-oval, placed obliquely on the sides of a deep split and so capable of close approximation. The usual ventral lobes of the disk are represented by two contiguous, roughly circular, dusky areas, (fig. 7) each with three or four tiny setae near the middle of its caudal margin. Anal gills (fig. 6) four in number, distinct, each gill rather short, simple, tapering gradually to the blunt tip.

The head-capsule is of the simple, generalized structure of this tribe, with flattened, mussel-like constituent plates. Labrum (fig. 1) transverse oval, the margin provided with short yellow hairs, a larger tuft on either side. On the disk are two oval subhyaline areas, each of which are provided with three sensory papillae; at either end of the labral sclerite a roughly conical chitinized supporting structure. Mentum (fig. 5) broad, the anterior margin gently convex and provided with 11 teeth, the median tooth largest, the others gradually decreasing in size to the outermost which is very small and indistinct;

the three intermediate teeth have the margins projecting as thin, pale wings. Hypopharynx (fig. 2) formed as in this tribe, a roughly circular chitinized collar provided with a crown of strong teeth that are curved strongly outward. Antennae (fig. 4) two-segmented, the last segment rather stout, cylindrical, slightly curved; the apical papilla is small but high, subhyaline. Mandibles (fig. 3) broad and flattened with a small dorsal tooth, and a row of five teeth along the ventral cutting edge, the outermost exceeding the apical point in size, the teeth thense decreasing in size to the basal one which is directed strongly basad. Maxillae of the usual generalized structure of this tribe, the inner and outer lobes subequal in size, densely hairy, the cardines large.

*Pupa.*—Length (including breathing-horns), 8-9 mm.; breathing-horns alone, 1.2-1.3 mm.
Width, dextro-sinistral, .85-.9 mm.
Depth, dorso-ventral, 1-1.05 mm.

Pronotal breathing horns grayish subhyaline. Head, thorax and sheaths of the appendages dark brown, becoming darker with age. Abdomen white or whitish, the chitinized terminal hooks and the transverse rows of spicules on the segments brown.

Cephalic crest small, indistinctly bilobed, distinctly set off from the antennal bases by deep grooves. Front long and parallel. Rostral sheath (fig. 12) very long and slender, subtended on either side by the sheaths of the paraglossae (fig. 12, Pa.); the latter project considerably beyond the tip of the former, extending to almost opposite the wing-tip; the rather acute apex of the rostrum ends just before midlength of the metatarsal sheaths. Margins of the cheeks prominent, flattened, as in this sub-tribe, overlying the knee-joint of the fore-legs. Antennal sheaths (fig. 8, Ant) short, ending slightly beyond the base of the wing-pad.

Pronotal breathing-horns (fig. 9) very long and prominent; viewed from the side (fig. 8) they are broadest before midlength where there is a distinct bulge on the anterior margin nearest the eye, thense tapering to the

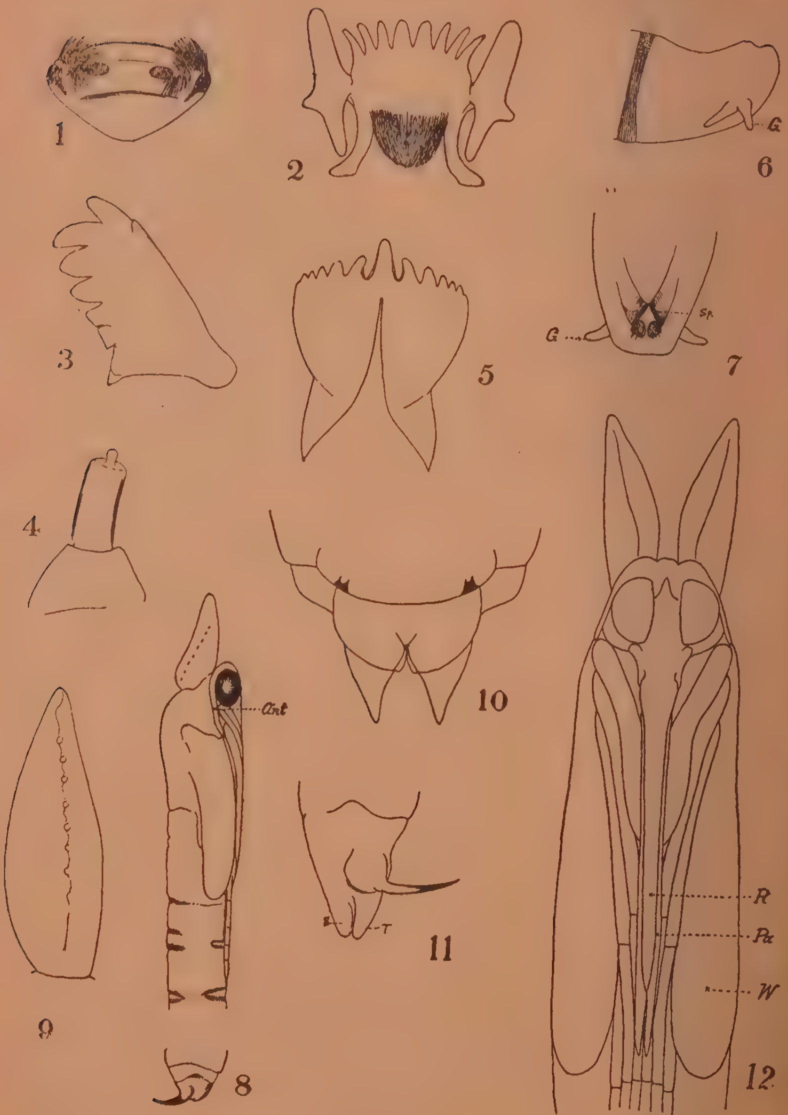
blunt tips. Viewed dorsally it is seen that the breathing-horns are not contiguous basally as in the genus *Elliptera* but are inclined proximad so that the tips touch one another, or nearly so; the dorsal margin is flattened and provided with about a dozen separated beathing-pores. Mesonotum smooth and not at all precipitous. Wing-sheaths rather long, ending opposite the base of the third abdominal segment. Leg-sheaths ending about opposite midlength of the fourth abdominal segment or slightly beyond, the tarsal sheaths ending nearly on a level or the two inner pairs a little longer than the outer pair.

Abdominal segments three to seven near the base are provided with two bands of chitinized hooks enclosing a transverse area, these interrupted on the venter by the leg-sheaths. There are about four or five distinct rows of hooks in each of these bands, those of the anterior band directed cephalad, those of the posterior band directed caudad, the hooks on the outer margin of these areas smallest, almost hair-like, the hooks increasing in size toward the enclosed area. Male cauda (fig. 10) chitinized, the tergal region produced into a powerful curved hook on either side, this bent strongly dorsad; in this sex the sternal valves do not project caudad beyond the level of this spine; in the female the sheaths of the ovipositor (fig. 11) project considerably beyond the spine which is thus situated at about midlength of the tergal valves.

*Nepionotype* (type larva), Alto Pass, Union County, Illinois, June 6, 1919 (Alexander and Malloch).

*Neanotype* (type pupa), with the type larva.

*Paratypes,* numerous larvae and cast pupal skins with the types; other material from the Campus of the University of Illinois, Champaign County, summers of 1917 (Malloch) and 1919 (Alexander).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## EXPLANATION OF PLATE

Ant—antennal sheath; G—gills; Pa—sheaths of the paraglossa; R—sheath of the rostrum; S—sternal valves of ovipositor; Sp—larval spiracles; T—tergal valves of ovipositor; W—wing sheath.

Fig. 1. Larva of *Geranomyia canadensis;* labrum.

Fig. 2. Larva of *Geranomyia canadensis*; hypopharynx.

Fig. 3. Larva of *Geranomyia canadensis;* mandible.

Fig. 4. Larva of *Geranomyia canadensis*; antenna.

Fig. 5. Larva of *Geranomyia canadensis;* mentum.

Fig. 6. Larva of *Geranomyia canadensis;* lateral aspect of caudal end.

Fig. 7. Larva of *Geranomyia canadensis;* dorsal aspect of caudal end.

Fig. 8. Pupa of *Geranomyia canadensis;* lateral aspect of male.

Fig. 9. Pupa of *Geranomyia canadensis;* dorsal aspect of pronotal breathing-horn.

Fig. 10. Pupa of *Geranomyia canadensis;* ventral aspect of male cauda.

Fig. 11. Pupa of *Geranomyia canadensis;* lateral aspect of female cauda.

Fig. 12. Pupa of *Geranomyia canadensis;* ventral aspect of male.

Papers on Geology and Chemistry.

# THE INTERCISION OF PIKE RIVER, NEAR KENOSHA, WISCONSIN

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J. W. Goldthwait, writing in School Science and Mathematics for February, 1908, uses the term "intercision" to describe a peculiar drainage modification effected by the waves of Lake Michigan. The term is one not common in physiographic usage. Goldthwait mentions several other instances of the same process and Cleland tells how the waves of the ocean may cut into the valley of a river in the same manner that Goldthwait has described.[1] Goldthwait's use of the term is referred to in quotation marks by Alden in his recent paper on the Quaternary Geology of Southeastern Wisconsin.[2] My purpose, however, is not to call attention to the use of a term, but rather to describe the process referred to. Intercision, as the term is used by Goldthwait, is an instance where a lake shortens the course of a stream by intercepting the stream somewhere between its source and its mouth. The conditions for such interception are rather exceptional and the event is a rare one in drainage changes.

Pike River finds the lower portion of its course incised in the plain of Glacial Lake Chicago. It crosses this plain in such manner that for nearly three and one-half miles it flows practically parallel to the shoreline of Lake Michigan. The direction of flow is towards the south. T. C. Chamberlin mentions the course of the stream as indicative of a southerly alongshore drift, that, in a higher stage of the Lake than at present, diverted the stream towards the south.[3]

The remnant of the lacustrine plain in this region is suffering rapid removal by the wave erosion of Lake Michigan. It is this fact, plus the parallel position of the stream in relation to shoreline that furnishes the setting for intercision. In respect to the retreat of the

[1] Cleland, H. F., Geology, 1916, p. 214.

[2] Alden, W. C., United States Geological Survey Professional Paper No. 106, 1918, p. 340.

[3] Chamberlin, T. C., Geology of Wisconsin, Vol. II, 1877, p. 130.

cliffs. Dr. Andrews, in 1870, found that the average retreat of the lake cliffs between Evanston, Ill., and Manitowoc, Wis., a distance of 180 miles, was 5.28 feet per year. The measurements on which his estimate was based ranged through a period of from 10 to 35 years.[4] In 1870, or thereabouts, he found the retreat of the cliffs at Kenosha to be as much as twelve feet in a year. In 1874, measurements furnished Dr. Chamberlin showed that at one place in Racine, Wis., the cliffs for 24 years had been receding at a rate of 9.73 feet per year.

Measurements recently completed near Kenoska indicate that the cliffs have retreated as much as 34 feet locally within a period of one year and seven months. The average retreat during this period, as indicated by eight measurements was 27.7 feet. The maximum retreat was found to be 34.2 feet; the minimum, 22.6 feet. The eight measurements mentioned above were taken within a distance of 2.5 miles. Taking the average retreat as a fair indication of the loss of land, the figures given represent the loss of a little more than eight acres within two years. The height of the cliffs ranges from 20 to 40 feet. The material of the cliffs is partly till, and partly stratified sands and clays deposited by Lake Chicago. The annual retreat of the cliffs as indicated at present approximates 17 feet as compared with the 12 foot retreat noted by Andrews.

That this rapid retreat of the cliffs is responsible for a marked diversion of the stream is shown in the following fashion. As the stream gradually approaches the lake, the continuity of its eastern valley wall is broken in two places. The breaks or breaches occur at places where the valley swings in meandering curves towards the lake. Through these wide breaches it is possible to obtain an open view of the lake from within the valley of the river. At the breaches the beach of Lake Michigan is built directly upon the flood plain of the river. Opposite the northernmost breach the river flows but fifty feet distant from the lake. Merely the

[4] Andrews, Dr. Edmund, The North American Lakes Considered As Chronometers of Post Glacial Time, Chicago Acad. of Sci., Vol. II, 1870, p. 7.

beach sands separate the waters of the river from the waters of the lake. It is easy to anticipate that at some time of flood or storm a channel will be opened across the beach for the river to follow. When this is done and the water of the stream diverted, the river will have suffered a second intercision.

This description of the present situation leads on to an interpretation of what has taken place in the past. About a mile south of the present mouth of the stream and along the shore, is a curving channel that has both ends open towards the lake. This abandoned channel is interpreted as a remnant of the former valley of lower Pike River. It has been utilized as part of the Kenosha harbor and locally is called a lagoon.

Several features, evident in the field, point to the proper connection of this abandoned channel with the former valley of Pike River (1) Several deposits of peat, similar to the peat now lying underneath the flood plain of the river, are exposed along the beach between the present mouth of the stream and the lower channel. (2) Near the present mouth of the stream a line of willows similar to the willows within the valley of the river continues south along the lake shore. Back of these willows the land descends in a gentle slope towards the lake instead of terminating in a sharp wave-cut cliff as it does elsewhere in the region. (3) A third, but not very conclusive evidence, lies in the fact that the abandoned channel is within the projected course of the meandering stream. (4) Pile driving operations south of the present mouth of the river encountered soft mud and logs in such a way as to suggest that the lake has entered in upon the flood plain of the lower part of the stream.

The evidence seems to be sufficient to suggest that the valley of the stream has been entered by the waters of the lake and the stream actually shortened in its course by more than a mile. When the second intercision takes place, if such an event occurs, the stream will be shortened again by at least one-half mile. And unless some means are adopted to check the migration of the cliffs

a third intercision may be anticipated with some degree of reason.

The rapid retreat of the cliffs is proving of serious import to property owners along the lake shore. In some cases the slumping of the cliff material is facilitated by the tile drainage of the uplands. The small, artificial streams directed by the tiles aid materially in the erosion of the steep cliffs. The retreat of the cliffs and the possibilities of the future intercision of the river give the situation a certain economic as well as physiographic interest.

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## NOTE OF A NEW INDICATOR IN WATER ANALYSIS

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The selection of an indicator for use in the titration of the bicarbonate alkalinity of natural waters has always presented some difficulty. Probably the first indicator used for this purpose, of which we have any record, was the coloring matter of red wine, for we are told that the Romans titrated natural waters with sour wine the red coloring matter of the wine acting as a natural indicator. Since that time other and better indicators have been suggested, it is true however that the selection of those suggested has often been made with very little more regard to the needs that the indicator must fill than was the original red wine of the Romans.

An examination of some of the more recent textbooks and reference books shows the following recommendations. Thresh (1913), Mason (1912), and Stocks (1912) recommend Methyl Orange. Leffman (1909) and Chemiker Kalender (1917) recommend Alizarin with Methyl Orange as an alternate. The first two editions of Standard Methods of Water Analysis A. P. H. A. recommend the use of either Lacmoid in hot solution or Erythrosine cold and advise against the use of Methyl Orange due to the difficulty of getting supplies of that indicator of sat-

isfactory quality. The third or (1917) edition of Standard Methods of Water Analysis, A. P. H. A. allows the use of Methyl Orange.

It will be seen from the above that Methyl Orange is the more popular indicator for this titration. The disadvantages of the others are so marked that it is hardly necessary to refer to them. The necessity of shaking the Erythrosine with chloroform makes its use tedious and slow. Lacmoid must be used in a boiling solution. This is a decided disadvantage. Methyl Orange can be used in a cold solution, works very satisfactorily in all cases excepting in water with an excess of alum. Methyl Orange indicates a slight residual alkalinity in a water in which all of the bicarbonate alkalinity has been used up by the addition of alum and even where there is a slight excess of alum in the water. Larger excesses of alum give an acid reaction. If such a case is suspected it is absolutely necessary to use some other indicator, such as Erythrosine or Lacmoid, which reacts acid to a dilute solution of alum.

While the end point change of Methyl Orange is very sharp and satisfactory to most chemists, quite often one finds chemists to whom the color change is very indefinite and difficult to distinguish. This is probably due to a slight color blindness but is nevertheless a real disadvantage of this indicator.

In 1916 Clark and Lubs[1] described a new series of indicators which they studied with reference to their use in the colorimetric determination of the hydrogen ion concentration. Acree and co-workers have studied the chemical structure and mechanism of color change of these indicators. The entire series without exception are brilliant colors and show a very marked color change at their neutrality point. One of these indicators tetrabrom phenol-sulphonpthalein changes color at a hydrogen ion concentration almost identical with that of methyl orange. The color change is from blue in alkaline to yellow in acid solution. This color change is much different from that of Methyl Orange and we feel that many

[1] W. M. Clark and H. A. Lubs, J of Bact. 2, 1-3, 109-136, 191-236 (1917).

people will find it much more easily detected. We have found it to be very satisfactory for use in titration of the bicarbonate alkalinity of natural waters. Table 1 gives a typical series of results. 50 cc. of water were used and duplicate titrations made with Methyl Orange and the tetra-bromphenol-sulphonphthalein. It will be noted that the variation between the results obtained with the two indicators is slight being practically no greater than would be found between duplicate determinations using the same indicator. The results tend to be somewhat higher since there is a constant difference, it could be eliminated by re-standardization of the standard acid using the new indicator. It was found that the titration could be carried out satisfactorily by ordinary electric light although the daylight was to be preferred.

TABLE I.

CUBIC CENTIMETERS OF N/50 SULFURIC ACID TO NEUTRALIZE 50 cc. OF WATER

| Sample Number | Observer No. 1 M. O. Day | B.P.B. Day | B.P.B. Night | M. O. Night | Observer No. 2* B.P.B. Day | B.P.B. Night | Observer No. 3 M. O. Night |
|---|---|---|---|---|---|---|---|
| 1 | 12.7 | .... | .... | .... | 12.5 | 12.5 | 12.5 |
| 2 | 15.7 | .... | .... | .... | 15.6 | 15.6 | 15.4 |
| 3 | 12.8 | .... | .... | .... | 13.1 | 13.1 | 12.9 |
| 4 | 11.4 | .... | .... | .... | 11.5 | 11.5 | 11.3 |
| 5 | 13.8 | .... | .... | .... | 13.9 | 13.9 | 13.7 |
| 6 | 12.5 | .... | .... | .... | 12.6 | 12.7 | 12.6 |
| 7 | 12.1 | .... | .... | .... | 12.4 | 12.4 | 12.2 |
| 8 | 7.7 | 8.0 | 8.0 | 7.9 | 7.9 | .... | .... |
| 9 | 8.3 | 8.5 | 8.4 | 8.3 | 8.4 | .... | .... |
| 10 | 5.5 | 5.6 | 5.7 | 5.6 | 5.6 | .... | .... |
| 12 | 7.7 | 7.7 | 7.8 | 7.7 | 7.6 | .... | .... |
| 13 | 1.4 | .... | .... | .... | .... | .... | .... |
| 14 | 11.0 | 11.2 | 11.3 | 11.0 | 11.1 | .... | .... |
| 15 | 15.5 | 15.7 | 15.5 | 15.9 | 15.5 | .... | .... |
| 16 | 5.7 | 5.8 | 6.0 | 5.8 | 5.9 | .... | .... |
| 17 | 4.1 | 4.2 | 4.5 | 4.2 | 4.2 | .... | .... |
| 18 | 21.3 | 21.5 | 21.8 | 21.5 | 21.4 | .... | .... |

B. P. B.=Tetra-brom-phenol-sulfonphthalein.

M. O. =Methyl Orange

* No Methyl Orange results obtained by observer number two on account of color blindness.

Titration with electric light using this indicator was however much easier than when Methyl Orange was used. One or two experiments with the so-called Daylight electric light indicated that the titration was [illegible] easily made with this light than when using ordinary electric light. Excess alum interferes in the same way as with Methyl Orange. Experiments have not been made in substituting this indicator for Methyl Orange in other titrations. We cannot say therefore whether it can be recommended as a general substitute for Methyl Orange but can recommend it as a substitute for Methyl Orange in the titration of bicarbonates with acid.

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## THE ABSORPTION OF THE OXIDES OF NITROGEN FORMED IN THE SILENT DISCHARGE

By F. O. Anderegg and K. B. McEachron, Purdue University

If the silent discharge process for the fixation of nitrogen is to be made sufficiently effective to compete commercially with other methods very efficient absorption of any oxides of nitrogen is quite necessary. In the arc fixation of nitrogen the question of complete absorption has received much attention because of the low concentration of nitric oxide produced. In the silent discharge process the most of the nitrogen which has been once brought into combination with the oxygen is probably oxidized completely so that it is readily absorbed in water. On the other hand the concentrations are apt to be rather low. Experiments with the silent discharge process are being carried out at the Engineering Experiment Station of Purdue University and considerable study has been given and more will be needed before the problem is solved. Since a report on this work is to be read at the Boston meeting of the American Institute of Electrical Engineers in April by C. F. Harding and K. B. McEachron, only such points as are pertinent to our subject will be discussed here.

Hautefeuille and Chappius[1] followed the course of the reaction when the silent discharge was passed through mixtures of oxygen and nitrogen by means of absorption spectra. A series of new bands was observed which was not characteristic of any of the bands of the oxides of nitrogen then known. On passing this new compound into water the water became acid and apparently only ozone was left in the gas. This peculiar compound seems to decompose on continued discharge, or slowly on standing, to lower oxides of nitrogen. This decomposition may be readily followed by changes in the absorption spectra. The formula, $N_2O_6$ was assigned to the compound as a result of analyses which were, however, widely divergent. Warburg and Leithäuser[2] have also studied this compound and have concluded that it is formed by the addition of ozone to nitrogen pentoxide.

Spiel[3] has made a very interesting study of the effect of the silent discharge on enclosed oxygen-nitrogen mixtures. At first there was a marked diminution in pressure which reached a limiting value. Then all of a sudden the pressure increased again nearly to the original value. Analysis of the gas at the point of minimum pressure showed the presence of 5-6% by volume of fixed nitrogen calculated as NO. After the reversal the pressure remained constant as well as the composition of the gas so long as the temperature remained constant. If the temperature, however, was allowed to rise after reversal then fluctuations in pressure were observed with corresponding changes in the amounts of oxides of nitrogen present. This tends to indicate the existence of a delicate electrical equilibrium which is easily distributed as a result of small temperature changes. The gas at the final equilibrium contained about 0.6% NO. At the lower pressures probably considerable amounts of the ozone-nitrogen pentoxide addition product were formed. During the reversal this was decomposed partly to molecular nitrogen, partly to nitric oxide and partly to nitrogen peroxide. This abrupt reversal appears rather

[1] *Compt. rend.* *92*, 80 (1881); *94*, 1111, 1306 (1882).
[2] Ann. Phys. 23. 204 (1907).
[3] Spiel, Dissertation, Vienna, 1909.

startling and so parts of this work have been repeated by one of us confirming Spiel's results as closely as could be expected considering the use of a different induction coil as source of power.

Very briefly the method used in the Purdue work has been to pass dry, carbon dioxide free, metered air down through that part of the discharge outside of the dielectric and up inside around the inner electrode where the most of the discharge occurs. The gas then passes into an apparatus containing broken glass tubing and standard alkali on the top of which are placed various traps to diminish the amount of entrapped liquid as much as possible. A large number of runs has been made at different velocities and different pressures. The results show a maximum in each case at a velocity of about 6 liters per minute. Beyond that the curve yield drops more or less rapidly. In the discharge there are at least two reactions going on simultaneously, an oxidation of some of the nitrogen and the reverse decomposition. The rate of the second reaction depends upon the concentration of the oxidized nitrogen. By increasing the flow of the gas this concentration is diminished and the amount of the reverse reaction approaches zero. According to this the greater the flow rate the greater the total fixation should be. Of course practically this reaches the limit. Here the limit is reached when the velocity of the gas becomes so great that the absorption is incomplete. However there are some other points that have arisen in connection with this maximum. From other reasons there is a suggestion that there might be a true optimum point at this maximum. An interesting side phenomenon which tends to accompany the absorption is the formation of fog above the absorption liquid. This fog forms about the molecules of nitrogen pentoxide or about the addition compound noted by Hautefeuille and Chappius. The fog reaches the greatest density at this velocity and until a small Cottrell electrostatic precipitator was included it escaped with resulting lowering of the observed yield. The appearance of this fog varies with the velocity and probably with the relative temperatures of the gas, liquid

and surroundings. At this optimum rate of flow there are noticed periodic vibrations in the pressures of the gas in the tube with corresponding fluctuations in the electrical recording instruments. This suggests a reversal similar to that noted by Spiel and suggests that at this velocity there is a tendency for the gases to reach a maximum concentration and then just before they can get out of the discharge perhaps a reversal starts to set in. This vibration effect was most noticeable at the higher pressures. More recently one of us has devised a more efficient means of absorption. The gas from the tube carries water to be atomized or broken up into a very fine spray so that the gas and the water are carried along together for some distance. By this simple method the yield especially at the higher velocity is somewhat increased.

Careful measurements have been made on the power input into the tube. Also the change in temperature of the gas, the porcelain dielectric and the electrodes have been noted using alcohol thermometers. Using standard specific heats 25-50 per cent of the energy put into the tube is not accounted for. This suggests that there might be a great deal more chemical action going on in the tube than is shown in the analyses. The amount of energy required to form the nitrogen peroxide and ozone observed by analysis will make up for only a small part of this discrepancy. There are at least two possibilities. Very likely some of the nitrogen is oxidized to only nitric oxide which is comparatively slowly oxidized and the gas passing through so rapidly would not be observed. For this reason it is proposed to use a mixing chamber so that it may be more completly oxidized. It is also proposed to try the effect of various catalytic agents. An allotropic modification of nitrogen might be produced which assumes a relatively stable form and escapes into the air. An active modification of nitrogen was first observed by E. P Lewis.[4] This modification has been much studied by R. J. Strutt.[5] This gas is best

[4] *Astrophys. J. 12,* 8 (1900); *20,* 49 (1904).
[5] *Proc. Roy. Soc. London A. 1911* to date.
(1904) Lafayette, Ind.

produced by a condensed discharge at about 3 mm. pressure from nitrogen which is almost but must not be obsolutely pure. More recently an ex-student of one of us, Mr. Grubb, now working with Dr. Wendt at Chicago, writes us that he has produced an active modification of nitrogen in the alternating corona. The term proposed is "nizone". They are studying the properties of this new substance. Whether it is the same as the Lewis-Strutt active nitrogen remains to be seen.

Work is being continued on this process but it is too early to prophesy whether it will ever be a commercial success or not. At all events it is hoped to make the absorption of the gases as complete as possible so that what is learned here may be applied to other problems involving the absorption of gases.

# CONSTITUTION AND BY-LAWS*

## Illinois State Academy of Science

### CONSTITUTION

#### Article I. Name

This Society shall be known as The Illinois State Academy of Science.

#### Article II. Objects

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

#### Article III. Members

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members.*

*National Members* shall be those who are also members of the American Association for the Advancement of Science. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

*Local Members* shall be those who are members of the local Academy only. Each local member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members, Active Members,* or *Non-resident Members.*

*Life Members* shall be national or local members who have paid fees to the Academy to the amount of twenty dollars. Life members, if national members, shall pay an annual assessment of four dollars.

*Active Members* shall be national or local members who reside in the State of Illinois, and who have not paid as much as $20.00 in fees to the Academy.

*Non-resident Members* shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

*Charter Members* are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the

* As Revised February, 1920.

committee on membership, and receive the assent of three-fourths of the members voting.

### Article IV. Officers

The officers of the Academy shall consist of a President, a Vice-President, a Librarian, a Secretary, and a Treasurer. The chief of the Division of State Museum of the Department of Registration and Education of the state government shall be the Librarian of the Academy. All other officers shall be chosen by ballot on recommendation of a nominating committee at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

### Article V. Council

The Council shall consist of the President, Vice-President, Librarian, Secretary, Treasurer, and the president of the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

### Article VI. Standing Committees

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

### Article VII. Meetings

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

### Article VIII. Publication

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

### Article IX. Affiliation

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

### Article X. Amendments

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

## BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting.

IX. The Secretary and Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

# List of Members Elected at Danville Meeting

**Note.**—Black faced letters indicate names of those who are also members of the American Association for the Advancement of Science.

**Abrams, Duff A.,** C. E. Lewis Institute, Chicago (Structural Materials).
**Acker, Frank J.,** 357 W. Erie St., Chicago (Chemistry).
**Adelsperger, Roland,** B. S., 5751 N. Clark St., Chicago (Safety in Building).
**Adler, Herman M.,** M. D., 119 E. Huron st., Chicago (Psychopathology, Criminology).
**Alexander, C. P.,** Ph. D., 419 W. Main St., Urbana, (Entomology).
**Allee, W. C.,** Ph. D., Lake Forest (Gen. Physiology).
**Alton High School Science Club,** Alton (General).
**Ames, E. S.,** Ph. D., University of Chicago, Chicago (Psychology).
**Andrus, J. C.,** B. A. Manchester (Astronomy & Botany).
**Bacon, Chas. Sumner,** Ph. D., M. D., 2156 Sedwick St., Chicago.
**Baber, Zonia,** B. S., 5623 Dorchester Ave., Chicago (Geography & Geology).
**Bangs, Edward H.,** 212 W. Washington St., Chicago (Agriculture & Electricity).
**Barnes, Cecil,** LL. B., M. A., 1522 1st Nat'l. Bk. Building, Chicago (Physical Geography).
**Bentley, Madison,** Ph. D., University of Ill., Urbana (Psychology).
**Block, D. Julian,** 1423 Rosemont Ave., Chicago (Chemistry).
Boot, G. W., M. D., 800 Davis St., Evanston (Medicine and Geology).
**Breed, Frederick S.,** Ph. D., 5476 University Avenue, Chicago (Education).
**Brown, George A.,** C. E., 304 E. Walnut St., Bloomington (Education).
**Buckingham, B. R.,** Ph. D., University of Illinois, Urbana (Education).
**Burmeister, William H.,** M. D., 1511 Congress St., Chicago (Experimental Medicine).
Calumet High School Biology Club, Chicago.
**Carman, Albert P.,** Ph. D., University of Illinois, Urbana (Physics).
**Clark, Albert Henry,** B. S., 701 S. Wood St., Chicago (Chemistry).
**Colby, Arthur Samuel,** Ph. D., 413 University Hall, Urbana, (Pomology and Pathology).
**Colby, Chas. C.,** Ph. D., University of Chicago, Chicago (Geography).
**Cone, Albert Benjamin,** 5245 Magnolia Ave., Chicago (Forestry, Microscopy).
**Culver, Harold E.,** Ph. M., State Geological Survey, Urbana (Geology).
**Danville Science Club,** Danville (General).
**Dart, Carlton R.,** B. S., 706 Greenleaf Ave., Wilmette (Civil Engineering).
**DeTurk, Ernest E.,** Ph. D., 707 W. Green St., Urbana (Soil Fertility).
**Doll, Theodore,** M. A., 913 Hamlin St., Evanston (Mathematics).
**Earle, C. A.,** M. D., Desplaines (Botany).
**Edgar, Thomas O.,** M. D., Dixon (Ophthalmology and Medical Science).
**Ehrman, E. H.,** M. E., 410 N. Kenilworth Ave., Oak Park (General).
**Eifrig, C. W. G.,** 504 Monroe Ave., Oak Park (Ornithology, Botany, Zoology).
**Elliott, Jesse E.,** Hoopeston.
**Eureka Science Club,** Eureka Twp., High School, Eureka.
**French, G. H.,** M. A., Carbondale (Botany and Entomology).
**Gaines, W. L.,** Ph. D., Urbana (Milk Production).
Georgetown Science Club of Georgetown H. S., Georgetown.
Gilman, Albert Franklin, Ph. D., Illinois Wesleyan University, Bloomington (Chemistry).
**Griffith, C. R.,** B. A., 209 University Hall (Psychology).
**Grodle, Harry S.,** M. D., 22 E. Washington St., Chicago (Ophthalmology).
Hanson, Alyda C., B. S., 246 N. H., University of Illinois, Urbana (Geography and Geology).
**Herrick, C. Judson,** Ph. D., Department of Anatomy, University of Chicago, Chicago (Neurology).

Higgins, George M., Ph. D., 714 W. Nevada St., Urbana (Zoology).
**Hoffman, Frank F.,** M. D., 2514 Smalley St., Chicago (Physician-Surgeon).
Hoffman, Leslie R., 213 Baker Ave., Joliet (Entomology).
**Holmes, Manfred J.,** B. L., 703 Broadway, Normal (Social and Education).
**Hoover, Harvey D.,** Ph. D., S. T. D., Carthage.
**Hopkins, B. Smith,** Ph. D., 706 W. California St., Urbana (Inorganic Chemistry).
**Horton, Edward R.,** North Henderson (Genetics-Eugenics).
**Jensen, Jens,** Ravinia (Geology-Botany).
**Johnson, T. Arthur,** M. D., 7th St. and 4th Ave., Rockford (Medicine, Science and Surgery).
**Johnson, C. N.,** M. A., D. D. S., 22 E. Washington St., Chicago (Prevention of Diseases).
**Jones, Elmer E.,** Ph. D., Northwestern University, Evanston (Mental Development-Heredity).
**Kauffman, J. S.,** M. D., 233 York St., Blue Island (Medicine).
**Koch, Fred Conrad,** Ph. D., 5532 Blackstone Ave., Chicago (Physiological Chemistry).
**Kuderna, J. G.,** M. S., Normal (Physical Science and Education).
**Laves, Kurt,** Ph. D., University of Chicago, Chicago (Astronomy and Mathematics).
**Leighton, Morris Morgan,** Ph. D., University of Illinois, Urbana (Geology).
**Lerche, Thorleif I.,** D. D. S., 3012 E. 92nd St., Chicago (Medicine).
**Lewis, Howard B.,** Ph. D., University of Illinois, Urbana (Physiology-Chemistry).
**Lukens, Herman T.,** Ph. D., 330 Webster Ave., Chicago (Geography).
**Magill, Henry R.,** 426 Forest Ave., Oak Park (Geology, Sociology, Finance).
**Malinovszky, A.,** 316 Portland Ave., Belleville (Chemistry).
**Mason, J. Alden,** Field Museum, Chicago (Anthropology).
**Miller, Isaiah Leslie,** M. A., (Mathematics and Chemistry).
Miller, P. H., Potomac (Biology).
Miller, R. B., M. F., 223 Nat. Hist. Survey, Urbana (Forestry and Ecology).
**Morrison, Elsie,** M. S., Mount Carroll (Botany-Ecology).
**Newcomb, Rexford,** M. A., University of Illinois, Urbana (Engineering Applications).
**Newell, M. J.,** M. A., 2017 Sherman Ave., Evanston.
Normal Science Club, Illinois State Normal University, Normal (General).
**Ondrak, Ambrose L.,** B. A., Lisle (Physics).
**Patterson, Cecil F.,** B. S., 610 West Illinois St., Urbana (Horticulture).
**Pollock, M. D.,** M. D., Powers Bldg., Decatur (Medicine and Surgery).
**Porter, James F.,** M. A., 1085 Sheridan Road, Hubbard Woods (Zoology).
**Potomac Twp. H. S. Science Club,** Potomac (General).
**Redfield, Casper L.,** 526 Monadnock Block, Chicago (Evolution).
**Rew, Irwin,** Ph. B., 217 Dempster St., Evanston.
**Rice, Arthur,** M. E., 537 S. Dearborn, Chicago (Engineering).
**Ruckmick, Christian A.,** M. A., Ph. D., 209 University Hall, Urbana (Psychology).
**Rudnick, Paul,** 10640 S. Seeley Ave., Chicago (Chemistry).
**Salter, Allen,** Lena, (Medicine).
**Schaub, Edward L.,** Ph. D., 2437 Sheridan Road, Evanston (Psychology).
Schantz, Orpheus M., No. 10 S. LaSalle St., Chicago, (Birds, Plants).
Seifert, Herbert F., M. A., Natural Hist. Bld., Urbana (Entomology).
**Siedenburg, Frederic,** M. A., 1076 West Roosevelt Road, Chicago (Sociology).
**Simonds, O. C.,** 1101 Buena Ave., Chicago (Botany).
**Simons, Etoile B.,** Ph. D., 7727 Colfax Ave., Chicago (Botany).
**Singer, H. Douglas,** M. D., 6625 N. Ashland Ave., Chicago (Psychiatry).
**Smith, Arthur Bessey,** B. S., 2324 Hartzell St., Evanston (Telephony).

**Smith, R. S.,** Ph. D., 653 Agricultural Building, Urbana (Chemistry and Physics of Soils).

**Smith, S. S.,** Menard (Gen. Vocat. and Physical Education).

**Sonnenschein, Robert,** M. D., 4534 Michigan Ave., Chicago (Medicine).

**Spencer, Ada V.,** B. A., Eastern Illinois State Normal School, Charleston (Zoology).

**Spooner, C. S.,** M. A., 704 N. Illinois St., Urbana (Entomology, Ecology).

**Tatum, Arthur L.,** Ph. D., M. D., University of Chicago, Chicago (Physiology and Pharmacology).

Thurlimann, Leota, 5955 Calumet Ave., Chicago (Botany).

**Van Cleet, Eugene,** B. S., 9616 S. Winchester Ave., Chicago (Commercial and Econ. Geography and Climatology).

**Von Zelinski, Walter F.,** M. D., Ph. G., 4709 N. Rockwell St., Chicago (Biology and Physiology).

**Warbrick, John C.,** M. D., M. C., 306 E. 43d St., Chicago (Birds and All Nature).

**Ward, Harold B.,** B. S., Northwestern University, Evanston (Geology and Geography).

**Weaver, George H.,** M. D., 629 S. Wood St., Chicago (Medicine and Bacteriology).

**Welker, William H.,** Ph. D., 5085 Honore St., Chicago (Biological Chemistry).

**Williams, E. G. C.,** M. D., Danville (Clinical Pathology).

**Witzemann, Edgar J.,** Ph. D., Sprague Mem. Institute, Rush Medical College, Chicago (Chemistry).

**Wright, Frank,** M. D., 5 S. Wabash Ave., Chicago (Biological Chemistry).

Wynne, Ross, B., A. B., 1409 E. 53d St., Chicago (Botany).

**Zimmerman, Augustine G.,** 30 N. Michigan Ave., Chicago (Biologic Science).

# List of Members

**Note**—The names of charter members are starred; names in black faced type indicate membership in the American association for the advancement of science.

## LIFE MEMBERS.

*__Andrews C. W.,__ LL. D., The John Crerar Library, Chicago (Sci. Bibl.).
*Bain, Walter G., M. D., St. John's Hospital, Springfield (Bacteriology).
**Barber, F. D.,** M. S., Illinois State Normal University, Normal (Physics).
Barnes, R. M., LL. B., Lacon (Zoology).
**Barnes, William,** M. D., Decatur (Lepidoptera).
*__Bartow, Edward,__ Ph. D., University of Iowa, Iowa City.
**Chamberlain, C. J.,** Ph. D., University of Chicago, Chicago (Botany).
**Chamberlin, T. C.,** LL. D., University of Chicago, Chicago (Geology).
**Cowles, H. C.,** Ph. D., University of Chicago, Chicago (Botany).
*__Crew, Henry,__ Ph. D., Northwestern University, Evanston (Physics).
*__Crook, A. R.,__ Ph. D., Chief State Museum, Springfield (Geology).
**Deal, Don W.,** M. D., Leland Office Building, Springfield (Medicine).
**Farrington, O. C.,** Ph. D., Field Museum, Chicago (Mineralogy).
**Ferriss, J. H.,** Joliet (Conchology).
**Fischer, C. E. M.,** M. D., Marshall Field Annex Bldg., Chicago (Biology).
*__Forbes, S. A.,__ LL. D., State Entomologist, Urbana (Zoology).
**Fuller, Geo. D.,** Ph. D., University of Chicago, Chicago (Botany).
*Gates, Frank C., Ph. D., State Agricultural College, Manhattan, Kan. (Botany).
Hagler, E. E., M. D., Capitol and Fourth Sts., Springfield (Oculist).
**Hankinson, Thos. L.,** A. M., N. Y. Coll. Forestry, Syracuse (Zoology).
*__Hessler, J. C.,__ Ph. D., James Millikin University, Decatur (Chemistry).
Hinkley,[1] A. A., Dubois (Conchology).
**Hoskins, William,** 111 W. Monroe St., Chicago (Chemistry).
Hunt, Robert I., Decatur (Soils).
**Jordan, Edwin O.,** Ph. D., University of Chicago, Chicago (Bacteriology).
**Kunz, Jacob,** Ph. D., 1205 S. Orchard St., Urbana (Physics).
Latham, Vida A., M. D. D. D. S., 1644 Morse Ave., Chicago (Microscopy).
Lillie, F. R., Ph. D., University of Chicago, Chicago (Zoology).
**Marshall, Ruth,** Ph. D., Rockford College, Rockford (Zoology).
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